BRISTOL

560/570/571

INSTRUCTION NO. 67A 2,272

WIDE-STRIP DYNAMASTER PYROMETER

USING SERIES L10 AMPLIFIER

INSTRUCTIONS

INSTALLATION
OPERATION
& SERVICE

ACCO BRISTOL DIVISION
WATERBURY, CONNECTICUT 06720

AMERICAN CHAIN & CABLE COMPANY, INC.

PLACE THESE INSTRUCTIONS WITH THE MAN IN CHARGE OF YOUR INSTRUMENTS

I M P O R T A N T

- Read these instructions NOW before installing instrument.
- Keep these instructions permanently & accessibly filed for future reference.
- Be sure to specify MODEL & SERIAL numbers when ordering parts, instructions, diagrams or data.
- Ship instruments or parts for repair or exchange only to Bristol's main or branch factories—not to Sales Offices.
- Be sure to—
  1. Identify your shipments with your exact return address & order number.
  2. Write nearest Bristol Factory or office giving your order number, directions & address for return shipment, full instructions for repair, etc.
- Report damage to shipments at once to shipping company. The **customer assumes responsibility for collecting** any claim for damages from the shipping company, on all shipments made on a collect basis.

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Experts in their jobs, these engineers provide you with instrument maintenance and repair service. Yet the training and administrative expenses normally associated with these functions are eliminated. To learn more of how these factory trained engineers can save you time, money and trouble contact your nearest Bristol Branch Office or The Bristol Division, Waterbury, Connecticut 06720.

ACCO **BRISTOL** DIVISION
WATERBURY, CONNECTICUT 06720

INDEX PAGE PG570-B
ISSUE NO. 1 OF 9/64

560/570/571

INSTRUCTION NO. 67A2272

WIDE-STRIP DYNAMASTER PYROMETER

USING SERIES L10 AMPLIFIER

FOR SERIAL NO. _____ CUST. ORDER NO. _____

ITEM	DESCRIPTION	NUMBER
1	Installation and Service of Case and Recording System	Y19820
2	Operation and Service of Balance System	P12050-B
3	Service Instructions for Series L10 Amplifier	P12606
4	Installation and Service of Thermocouples	P12500
5	Thermocouple Calibration Data	P12514
6	Parts List for Dynamaster Recorder	P12055-A
7	Parts List for Series L10 Amplifier	P12609
8		
9		
10		
11		
12		
13		
14		
15		
	PLUS FOLLOWING ITEMS AS REQUIRED	
	INSTRUCTIONS	
		Y19822
		Y19208
		P12170-23-A +
		RF-212
	WIRING DIAGRAMS	
		021996
		020763-24-B
		012678
		015058

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INSTRUCTION NO. Y19820
MODEL 560, 570, & 571 CASE
AND WIDE-STRIP RECORDING SYSTEM

- TABLE OF CONTENTS -

	Page
PART I INSTALLATION	2
A. Unpacking the Instrument	2
B. Locating and Mounting the Instrument	2
C. External Wiring and Piping	2
D. Installing the Chart	3
E. Installing and Starting Fountain Pens	3
F. Installing Ball-point Pens	3
PART II SERVICE	4
A. Lubrication	4
1. Balancing Motor	4
2. Multiple-point Recorders	4
B. Care of the Pen in the Single-pen and Two-pen Recorders	4
C. Care of the Print Wheel in Multiple-point Recorders	4
D. Lining up the Chart	4
E. Setting the Mechanical Zero	6
F. Adjusting the Rewind-spindle Clutch	6
G. Adjusting the Feed-roll Clutch	6
H. Replacing or Adjusting the Pen or Print-wheel Drive Cord	7
J. Changing Chart Speeds	7

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WATERBURY, CONNECTICUT 06720

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Note: This instruction covers the installation and service of the case and wide-strip recording system only. See separate instructions furnished covering the basic balancing, amplifying and switching systems in the Bristol Dynamaster Potentiometer, D-C Bridge or A-C Bridge-type Instruments. See also separate instructions covering measuring elements, controls, alarms, etc., as required.

PART I INSTALLATION

A. Unpacking the Instrument

Do not throw away the packing material until you have found the mounting brackets and screws as shown in the mounting-dimension drawing, and the other accessories, such as ink, charts, spare parts, etc.

B. Locating and Mounting the Instrument

The Dynamaster may be surface mounted or flush panel mounted. Although the instrument is exceptionally free from the effects of dust, dirt, vibration, corrosive fumes and extremes of temperature, it should be located as remotely as possible from such unfavorable conditions. The location should also be convenient for service and general utility.

The instrument should be reasonably level. Proper clearance should be allowed between the Dynamaster and other instruments on the wall or panel, and clearance must be given at the bottom of the case for the wiring or piping connections.

C. External Wiring and Piping

Before connecting any wiring to the Dynamaster, check the voltage and frequency listed on the nameplate of the instrument. To connect the Dynamaster to any voltage other than 120 volts, a suitable transformer must be used. All wiring connections are made on the terminal strips mounted inside on the back of the case. The terminals are readily accessible by opening the door of the Dynamaster and swinging the panel out after first depressing its latch.

The instrument is provided with four holes in the bottom of the case to accommodate standard conduit fittings. Two of the holes accomodate 1 1/4" conduit connections and the other two accommodate 3/4" conduit connections. Conduit should be used whenever possible to bring all electrical circuits into the case. If conduit is not used, the rubber grommets supplied with the instrument should be used by punching a small hole in the center of the grommet.

The wiring diagrams for your particular Dynamaster are provided separately. The measuring circuit is usually covered on one sheet and the power circuit on another sheet. If your instrument is equipped with an electric control or alarm, a third diagram will be furnished covering its wiring.

When connecting the power line to the instrument, make sure that the grounded side of the line is connected to the right-hand power terminal.

A good ground must be connected to the terminal marked GND.

Note: Do not install measuring circuits such as thermocouple wires in the same conduit with higher-voltage lines.

Piping or tubing will be required if a pneumatic control is supplied in the instrument. Air-control instruments are provided with case connections in the bottom of the case for standard 1/4" pipe or 3/8" copper tubing.

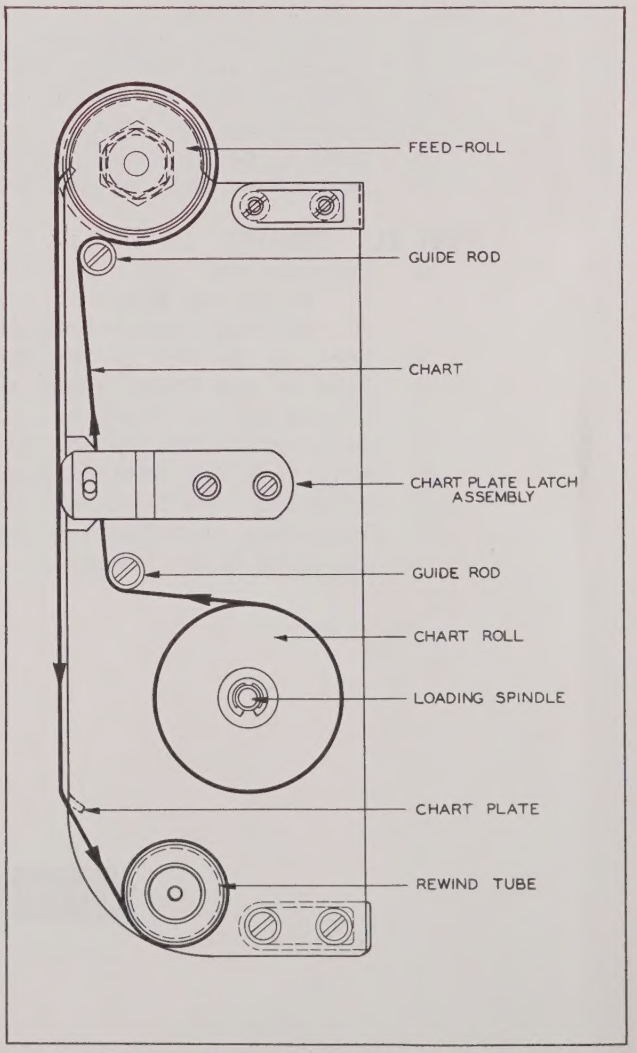

FIGURE I. CHART INSTALLATION DRAWING

D. Installing the Chart

A new chart roll must be flush with the left end of its tube. Before installing the chart, tap the left end (end with the round holes) on a flat surface to make sure that the tube and chart are flush. Release the chart-plate latch and swing out the chart plate. Fit the new chart roll onto the loading spindles (Fig. 1) with the round feed holes on the left. Thread the chart over the guide rods and under and around the feed roll (see Fig. 5). Latch the chart plate and attach the free end of the chart to the rewind tube with the clip provided. Take about 1 1/2 turns around the rewind tube and fit the tube onto the rewind spindles so that the key on the right rewind spindle fits into the slot in the tube. Tighten the chart by turning the rewind-spindle knob counterclockwise.

E. Installing and Starting Fountain Pens

Fountain pens are packed with the other accessories included with the instrument. Before installing the fountain pen or pens, the pen reservoirs must be filled with ink and the ink sucked thru the pen point by means of the pen starter provided. Then insert the pen or pens in the pen bracket, making sure that the pins on the pen go completely into the slots in the pen bracket. See Fig. 2 for installation of pens in 2-pen instruments.

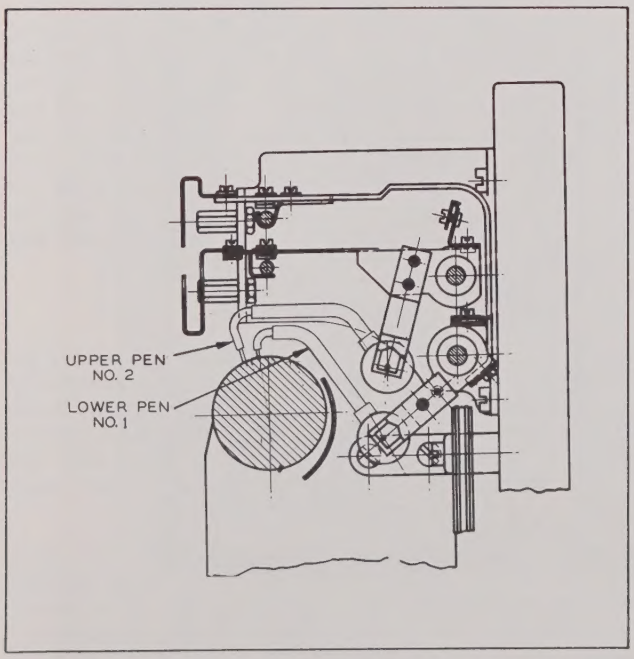

FIG. 2. INSTALLATION OF PEN ON TWO-PEN RECORDERS.

Multiple-point recorders are shipped with the print wheel and inked felts already installed.

F. Installing Ball-point Pens

Ball-point pens use a special mounting bracket as shown in figure 3.

To replace a ball-point pen, remove the cartridge end from the hole in the bracket and unscrew the pen end. Screw in the new pen and place cartridge end in bracket hole as shown in figure 3.

A ball-point pen should exert a force of approximately 15 grams on the chart paper for optimum recording results with a wide range of writing velocities. The mounting bracket design for this attachment assures the correct angle and pressure for this pen. The pen mounts perpendicular to the chart paper. The ink supply must always be above the ball-point, and the bending radius of the cartridge should not be less than 1/2 inch.

Ball-point pens are available in the following ink colors: Red, Part #A8253; Blue, A8254; Green, A8255; and Black, A8256.

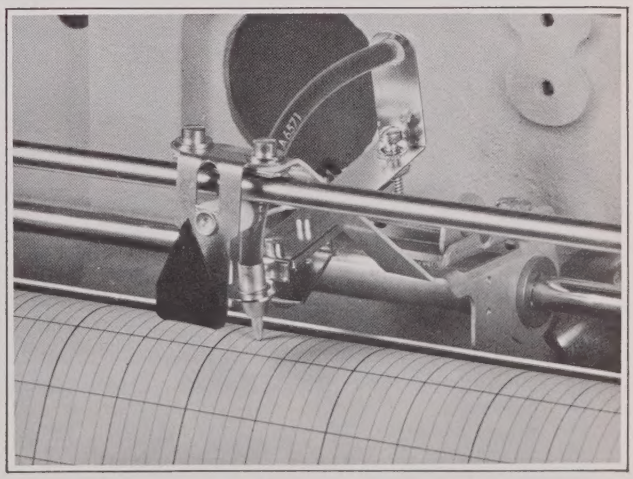

FIGURE 3. ATTACHMENT T113 BALL-POINT PEN

PART II SERVICE

A. Lubrication

1. Balancing Motor. Present motors, equipped with open gear train, have ball bearings which require no lubrication. However, the fibre gear that meshes with the motor pinion should be oiled with 2 or 3 drops of Gulf electric motor oil about once every six months. This light oiling of the fibre gear helps to prolong its life.

2. Multiple-point Recorders. The multiple-point Dynamaster requires lubrication of the print-wheel assembly and switching mechanism. There are three oil holes in the print-wheel assembly (Fig. 4). Oil these points once a year with Gulf electric motor oil.

There are three oil holes in the gear train of the switching mechanism. They should be oiled once a year.

The selector-switch contacts are normally self-cleaning. If it should be necessary to clean these contacts, they should be cleaned with a cloth and a solvent such as Bristol cleaning fluid Part A5700. After cleaning, the contacts should be lubricated with a very thin film of Cramolin. It is not necessary to remove the brush arm when cleaning the contacts. The brush arms may be rotated **counterclockwise** without damaging the unit or getting the print wheel out of step. If the brush arm is ever removed, note carefully the contacts on which the brush arm rests so that it may be returned to the same position. In addition to locating the brush arm correctly, the brush arm assembly should be pressed firmly against the hub of the switch-contact plate before tightening its setscrew. This guarantees the correct pressure on the contacts. Starting on or about June 1, 1954, the switch-contact-plate hub will have a locating pin that fits into a hole in the brush-arm assembly. In this way, if the brush arm is taken off, the brush arm can be easily and correctly returned to its synchronized position. Always push brush arm tightly against hub of contact plate before retightening its setscrew.

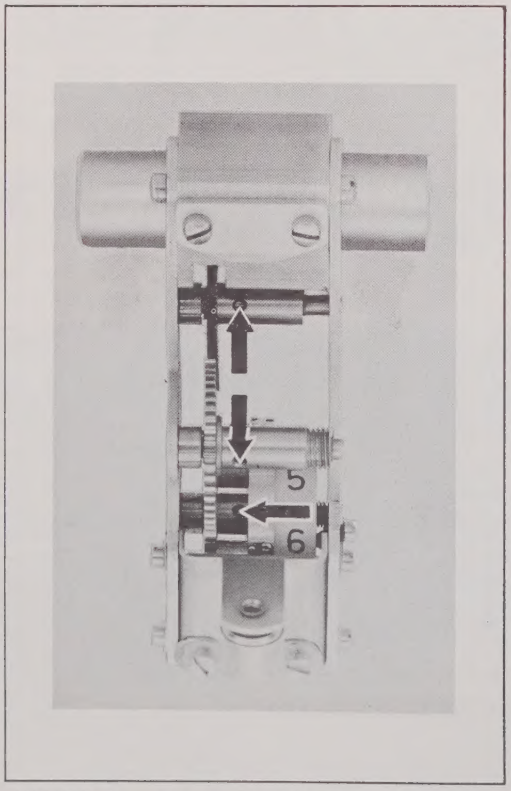

FIGURE 4. PHOTO SHOWING OIL HOLES ON PRINT WHEEL ASSEMBLY.

Holtzer-Cabot gear case motors with oil cup, used on the multiple-switching mechanism and when required on chart drives, should be oiled every **3 months** with **3 cc's** of Houghton Gearlub 890 (Bristol Part No. 91982 for 2 ounce can).

Nothing else should be oiled in the Dynamaster. All other bearings are either dry (and should be kept clean) or are permanently sealed and require no lubrication during their normal lifetime.

B. Care of the Pen in the Single-pen and Two-pen Recorders

The pen should be kept at least a quarter full of ink. If it clogs or draws a poor record, clean it with the wire pen cleaner provided. If necessary, wash the pen with soap and warm water.

C. Care of the Print Wheel in Multiple-point Recorders

When the printed record becomes too light for easy reading, the ink pads should be changed. The single-color ink pad may be replaced by removing the thumb nut and sliding off the old pad. The multi-colored pads should be replaced one at a time so that the color sequence will not get mixed up. When replacing the pad holder in the multi-colored unit, be sure to line up the pin in the holder with the hole in the gear and the hole in the indicating disk.

D. Lining up the Chart.

It is extremely important that the chart be correctly lined up. This is done very carefully at The Bristol Factory and should seldom need adjustment. However, if the left-hand guide pins on the feed roll should tear or distort the holes in the chart, the chart must be realigned as follows:

If the chart tends to tear on the left side of the holes, loosen setscrew in loading-spindle adjusting nut and turn adjusting nut in a clockwise direction until chart feeds properly. While making this adjustment, hold onto the collar located to the left of and on the same shaft

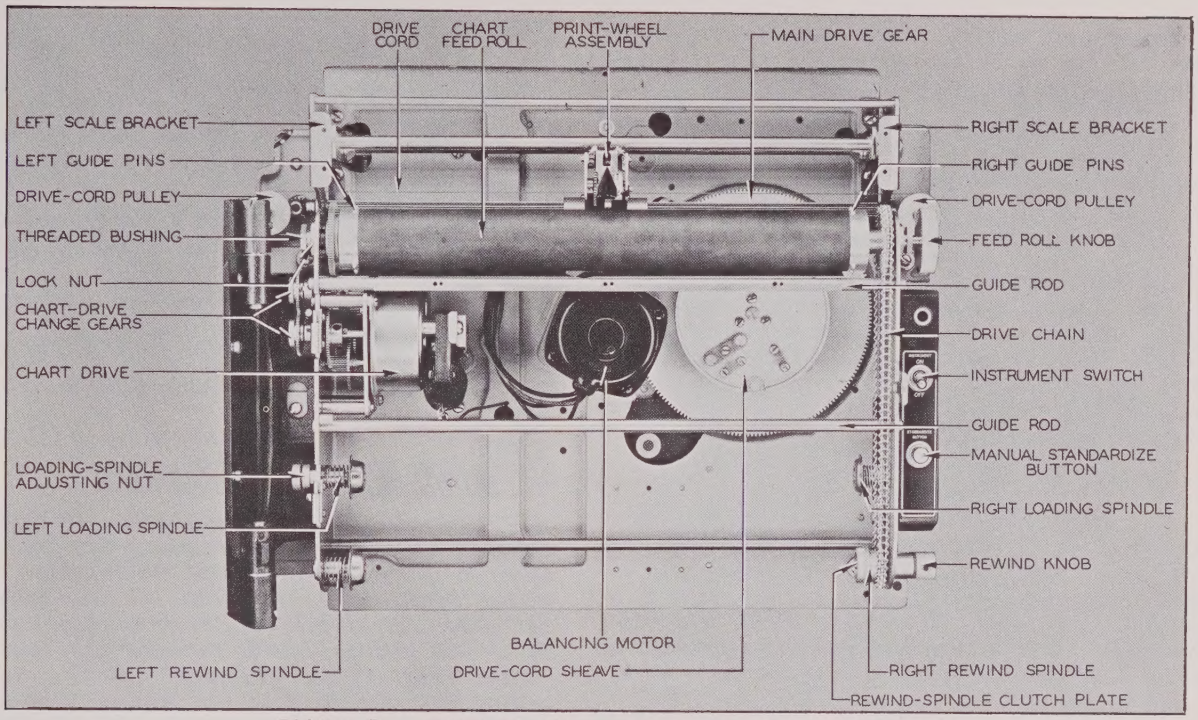

FIGURE 5. FRONT OF PANEL, MULTIPLE-POINT DYNAMASTER

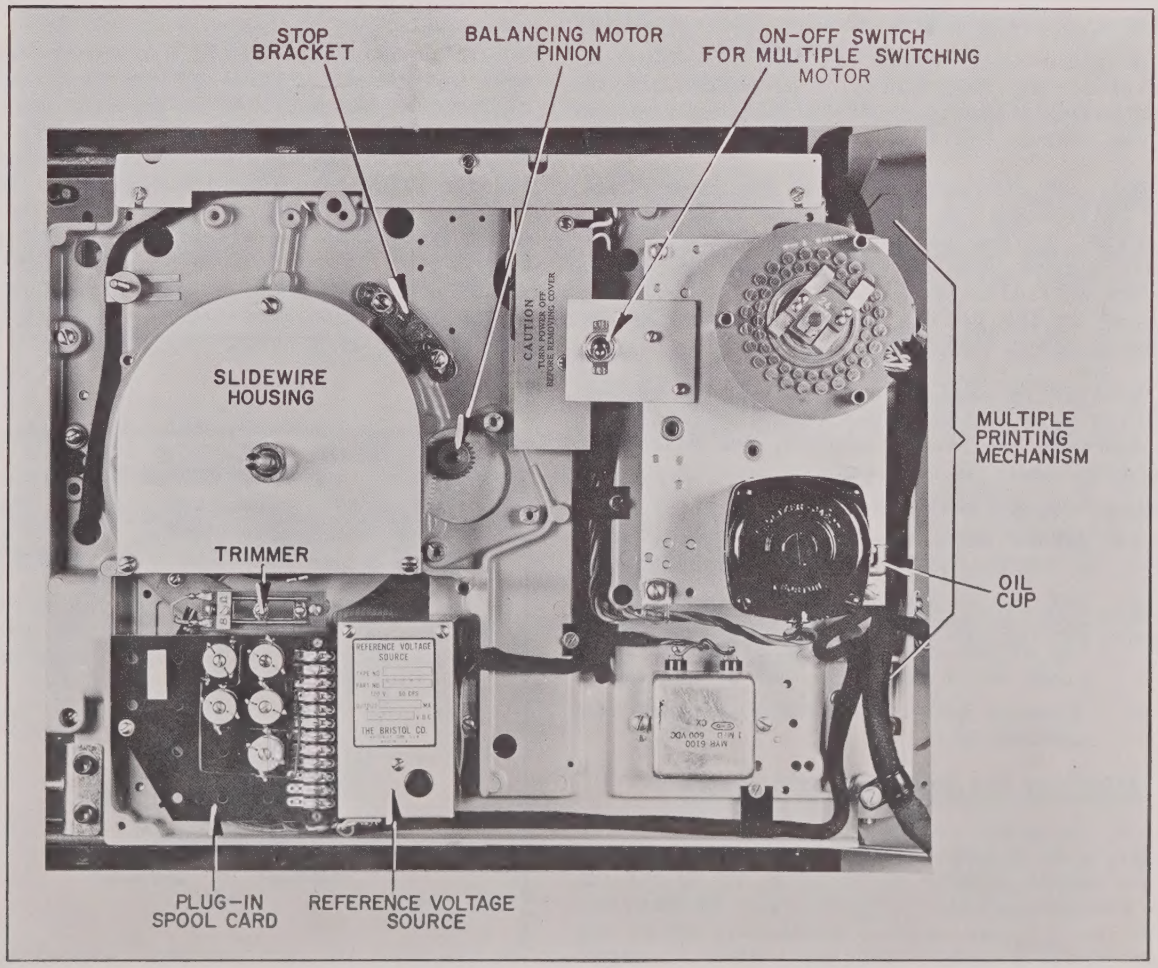

FIGURE 6. BACK OF PANEL, MULTIPLE-POINT DYNAMASTER POTENTIOMETER

as the adjusting nut. This prevents the shaft from turning while the adjusting nut is being turned.

If the chart tends to tear on the right side of the holes, turn adjusting nut in a counter-clockwise direction until chart feeds properly.

If the chart tends to tear on the back side of the holes, the rewind-spindle clutch is too tight. To loosen clutch, turn rewind-spindle clutch plate counterclockwise (see Fig. 5). There are 2 holes in this plate into which any small metal object (such as a nail or paper clip) can be inserted to turn it. (See Par. F.)

E. Setting the Mechanical Zero

All Bristol Dynamaster Wide-Strip Recorders shipped after December 15, 1953 will be adjusted to have a live zero. The mechanical stop on these instruments will be set so that the pen is mechanically stopped at a point .035" below the live zero. This mechanical stop is referred to as the stop bracket in Figures 5 and 6.

As rapidly as possible, all wide-strip charts will be reprinted with a dotted line .035" below the live zero to indicate the position of the mechanical stop.

On older instruments not already adjusted to a live zero, the following procedure should be followed in resetting the mechanical zero to the new charts.

Turn off instrument. Rotate the large drive gear until stop pin hits the low side of stop bracket. If pen is not on the dotted line, loosen screws holding stop bracket and shift bracket sufficiently to permit pen to be moved to rest on the dotted line. Then retighten screws holding stop bracket.

When it is necessary to install a new pen or drive cord, or whenever the setting of the pen carriage has been disturbed, the following procedure should be followed:

1. Turn off instrument.
2. Rotate the large drive gear until stop pin hits the low side of stop bracket.
3. Set pen on dotted line below the live zero, by loosening drive-cord clamp on top of pen carriage and slide pen carriage until pen is on the dotted line.
4. Tighten drive-cord clamp and turn on instrument.

F. Adjusting the Rewind-spindle Clutch

If the chart rewind tube slips or rewinds loosely when the Dynamaster is operating, tighten the rewind-spindle clutch (Fig. 5) by turning the rewind-spindle clutch plate clockwise. There are 2 holes in this plate into which any small metal object (such as a nail or paper clip) can be inserted to turn it.

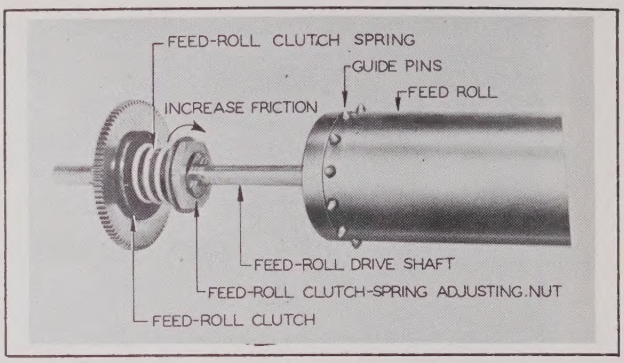

FIGURE 7. FEED ROLL CLUTCH

G. Adjusting the Feed-roll Clutch

The feed-roll clutch has been carefully installed at the Bristol factory and generally never requires adjustment. Under usual operating conditions, however, it may lose its friction. If it does not feed the chart smoothly at the correct rate, inspect the feed-roll clutch (Fig. 7) for slippage. By removing the rewind roll and turning the feed-roll knob, the clutch tension can be felt. The feed roll should **not** turn freely. If it does, the clutch is probably slipping.

To tighten the clutch, the entire feed roll must be removed. Take off the feed-roll knob and unscrew the setscrew in the feed-roll sprocket so that the sprocket turns freely. Remove both threaded bushings with their lock nuts, being careful not to lose the bearings. Move the left end of the feed roll out beyond the chart-assembly bracket and withdraw it from the drive sprocket. Push the feed-roll drive shaft through the feed roll until the clutch-spring adjusting nut is accessible. Tighten the ad-

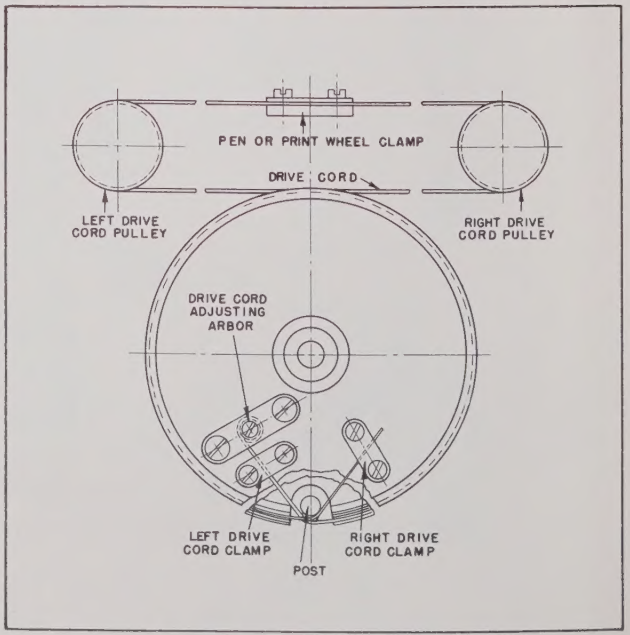

FIGURE 8. DRIVE CORD INSTALLATION DRAWING

justing nut until the clutch tension is sufficient to feed the chart correctly.

H. Replacing or Adjusting the Pen or Print-wheel Drive Cord

To replace a broken or worn cord, loosen the drive-cord clamp on the drive-cord sheave, loosen the drive-cord clamp on the print-wheel or pen assembly and take out the old cord (Fig. 8). Turn the drive-cord sheave so that the clamps are at the bottom. Thread one end of the new cord under the left drive-cord clamp and thru the adjusting arbor. Tighten clamp. Thread the cord around the post and the right-hand side of the sheave (in the rear groove), around the left drive-cord pulley, thru the hole in the left-hand scale bracket, thru the hole in the right-hand scale bracket, around the right drive-cord pulley, around the left-hand side of the sheave (in the front groove), around the post, thru the right drive-cord clamp on the sheave. Tighten the clamp. Make sure that the cord is on all the pulleys, then turn the adjusting screw clockwise to tighten the cord to the proper tension. It should be tight enough to prevent backlash but not so tight as to cause the drive-cord pulleys to bind. Tighten the left drive-cord clamp and clip off any excess cord which may remain beyond the arbor.

Now clamp the print-wheel or pen assembly to the cord. Be sure that the print wheel or pen is correctly zeroed by turning the main drive gear by hand until it hits the low stop. Center the pen or print wheel exactly on the lowest division of the chart (usually zero) and clamp the drive cord securely. (See Par. E. page 6).

J. Changing Chart Speeds

To change the chart speed on a Bristol Wide-strip Dynamaster, first remove the change-gear lock nuts and the change gears from their shafts. (See Fig. 9).

Find the chart-drive motor behind the chart plate and determine the make and speed of the motor from its nameplate. The nameplate is located on the end of Telechron motors and on the top of Holtzer Cabot motors.

Find the column for the particular motor you have in the table Fig. 21 of Parts List P12055-A. Read down that column to find the desired chart speed; then read across the table to the right to find the gear train required.

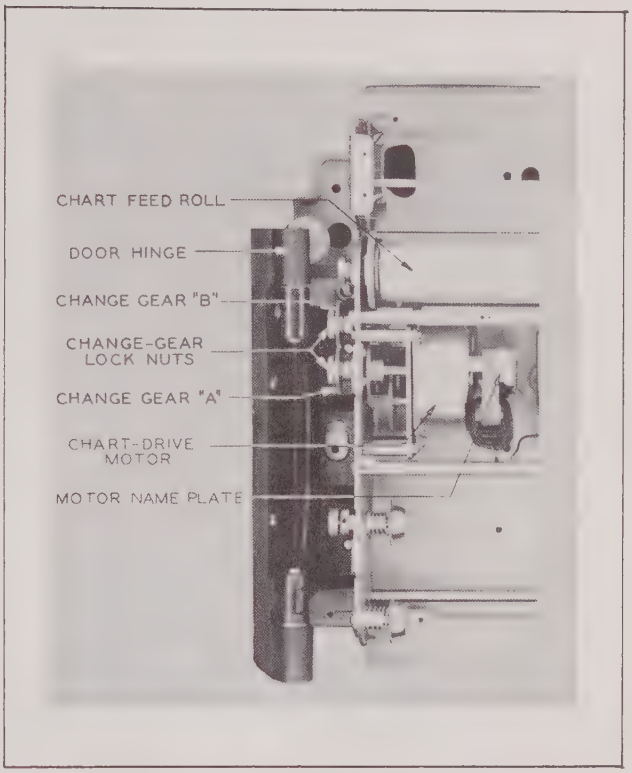

FIGURE 9. LEFT SIDE OF HINGED PANEL WITH CHART PLATE REMOVED

The number of teeth and the pitch should be marked on all gears with 32 or more teeth. If two gears with the same number of teeth are not marked for pitch, the smaller one is 48 pitch.

Put the gears on their respective shafts, making sure the "A" gear goes on the lower shaft. Be sure the slots in the gears engage the keys on the hubs so that they will not slip. Lock them in place with the change-gear lock nuts.

Note: If there do not appear to be enough gears for all the desired chart speeds, remember that each set of gears will give two speeds, depending on which gear is used as the "A" gear.

Spare chart-drive change gears are mounted on a stud located on the back of the hinged panel (upper left corner).

INSTRUCTION NO. P12050-B
SERIES 560, 570, ETC.
WIDE-STRIP DYNAMASTER® RECORDERS
FOR 1, 3, 4.5, 12, & 24 SEC. PEN SPEEDS
(USING SERIES L AMPLIFIER)

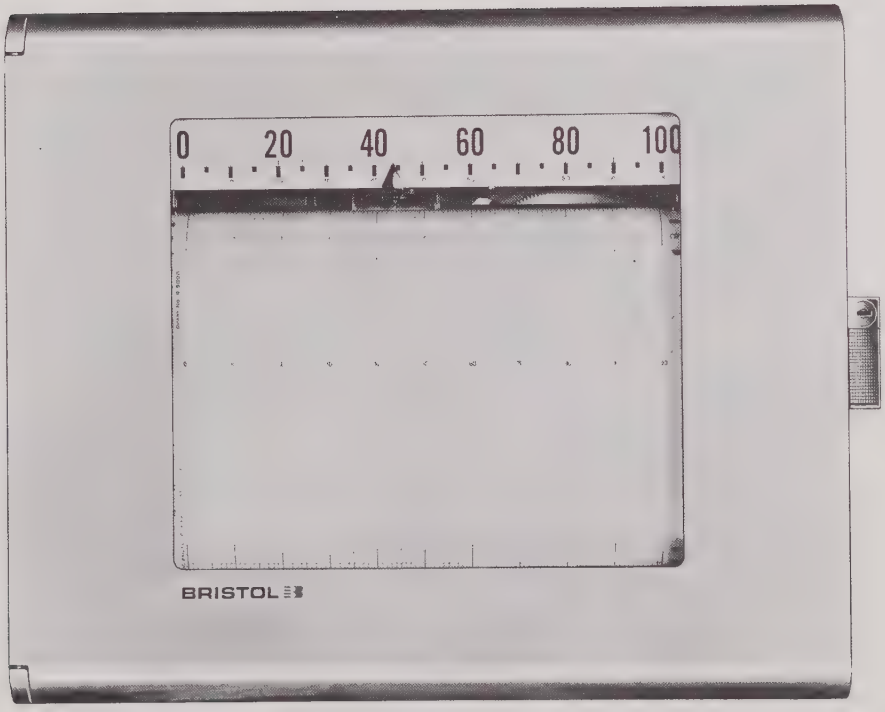

FIGURE 1. FRONT VIEW OF DYNAMASTER RECORDER

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WATERBURY, CONNECTICUT 06720

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TABLE OF CONTENTS

	Page
PART I GENERAL	3
A. Description	3
B. Principle of Operation	3
1. The Dynamaster Potentiometer	3
2. The Dynamaster D-C Bridge	3
3. The Dynamaster A-C Bridge	6
PART II OPERATION	
A. Starting the Dynamaster	6
B. Stopping the Dynamaster	6
C. Zener Diode Reference Voltage Source	6
D. Amplifier Gain Adjustment	6
1. On Single- and two-Pen Recorders	6
2. On Multiple-point Recorders	7
PART III SERVICE	
A. Suggested Service Equipment	7
1. Stock of Replacement Parts	7
2. Test Equipment	7
B. Systematic Trouble-shooting Procedure	8
1. Power-supply Check	8
2. Balancing Motor Check	8
3. Checking Amplifiers	8
4. Measuring System on Potentiometers	8
5. Measuring System on D-C Bridges	9
6. Measuring System on A-C Bridges	9
7. The Recording System	9
C. Miscellaneous Trouble-shooting Tips	10
D. Checking Calibration	10
1. On Potentiometers	10
2. On Bridge-type Instruments	10
E. Repairs, Correspondence and Shipping	11

LIST OF ILLUSTRATIONS

Figure 1.	Front View of Dynamaster Recorder	1
Figure 2.	Front of Panel, Multiple-point Dynamaster Recorder	4
Figure 3.	Back of Panel, Multiple-point Dynamaster Potentiometer	4
Figure 4.	Back of Panel, Single-point Dynamaster Potentiometer	5
Figure 5.	Interior of Case	5

PART I GENERAL

NOTE: This instruction covers the basic balancing and amplifying systems in the Bristol Series 560, 570, etc., Wide-strip Dynamaster Recorders. See separate instructions covering case installation, recording systems, measuring elements, controls, etc.

A. Description

The **Dynamaster Potentiometer** is used with any millivoltage input such as that from thermocouples, photoelectric cells, shunts, magnetos, pH amplifiers, etc.

The Dynamaster D-C Bridge is used with a very low range resistance type measuring element, such as resistance thermometer bulbs, strain gauges, etc.

The Dynamaster A-C Bridge is used with any resistance type of measuring element, such as resistance thermometer bulbs, conductivity cell, etc. The a-c bridge should not be used where a-c pickup is a problem.

Both single- and two-pen recorders are available as well as multiple-point recorders capable of recording up to 24 variables.

The major components of the instruments are :

1. The potentiometer or bridge circuit
2. The Syncroverter® switch
3. The input transformer
4. The amplifier
5. The balancing motor
6. The recording system
7. The multiple-point switching system (used only in the multiple-point recorders)

B. Principle of Operation

1. The Dynamaster Potentiometer. A potentiometer measures an emf of unknown value by comparing it with a known emf. In the Dynamaster potentiometer, the millivoltage input from the sensing element is connected in series with the potentiometer circuit and Syncroverter switch. A standard voltage, supplied by a Zener diode reference voltage source in the potentiometer circuit, is automatically adjusted to balance any change in the millivoltage input. Any change in the measuring-element voltage creates a d-c voltage unbalance in the potentiometer circuit. This d-c voltage unbalance is converted to an a-c voltage unbalance by the Syncroverter switch. The Syncroverter a-c unbalance output voltage is then increased by the amplifier to a power level sufficient to operate the balancing motor. The balancing motor adjusts the sliding contact on the slidewire to restore electrical balance in the potentiometer circuit and simultaneously moves the pen and pointer to record and indicate, on the chart or scale, the value of the variable being measured.

The balancing action starts with the slightest change in the output voltage of the sensing element. Thus, recording and indicating of the measured quantity are practically instantaneous.

When balance has been restored, the entire potentiometer remains at rest until another change in the measured variable occurs.

2. The Dynamaster D-C Bridge. In a D-C bridge, the measuring element forms one leg of the d-c bridge. A d-c power pack supplies 7 to 9 volts d-c to the bridge circuit. When the resistance of of the measuring element changes, current flows in the bridge and a d-c voltage unbalance is created in the bridge circuit. This d-c voltage unbalance is converted to an a-c voltage unbalance by the Syncroverter switch. The Syncroverter a-c unbalance output voltage is then increased by the amplifier to a power level sufficient to operate the balancing motor. The balancing motor adjusts the sliding contact on the slidewire to restore electrical balance in the bridge circuit and simultaneously moves the pen and pointer to record and indicate, on the chart or scale, the value of the variable being measured.

This balancing action starts with the slightest change in the resistance of the

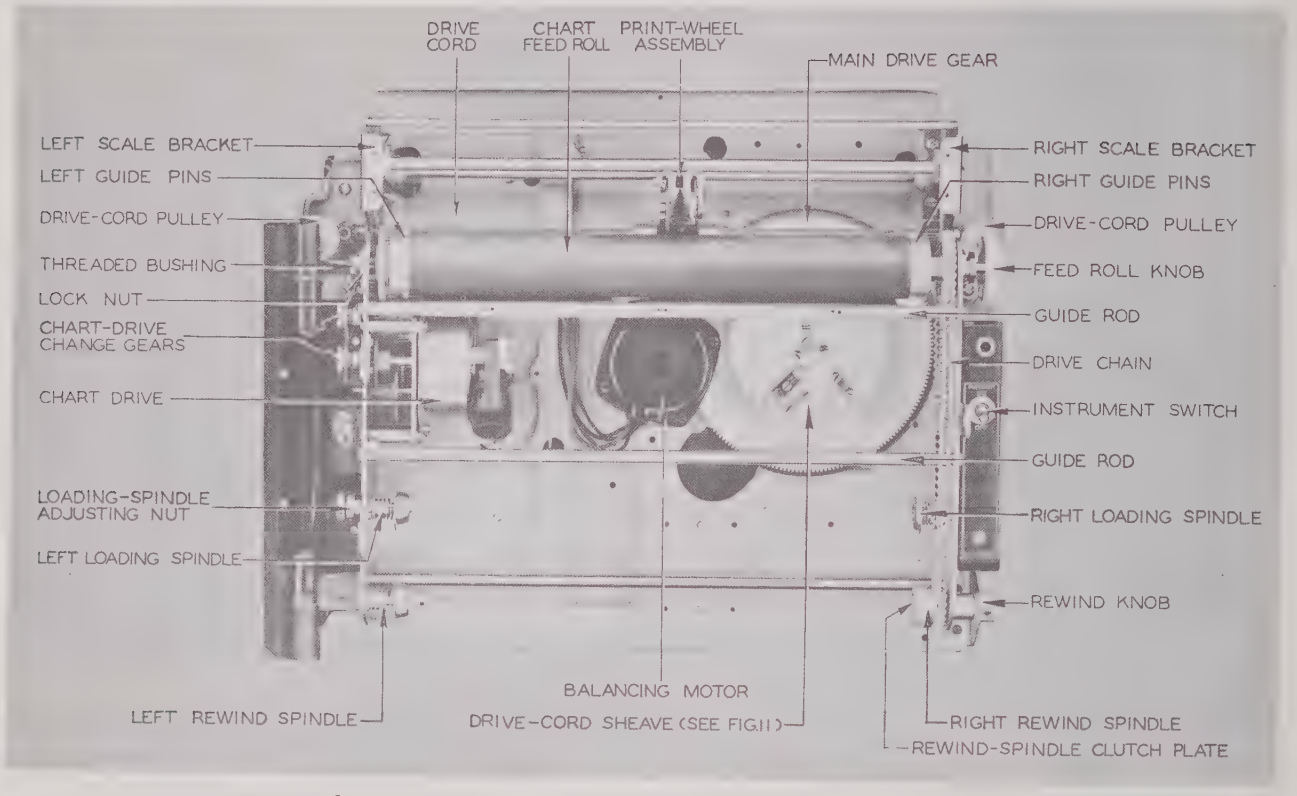

FIGURE 2. FRONT OF PANEL, MULTIPLE-POINT DYNAMASTER RECORDER

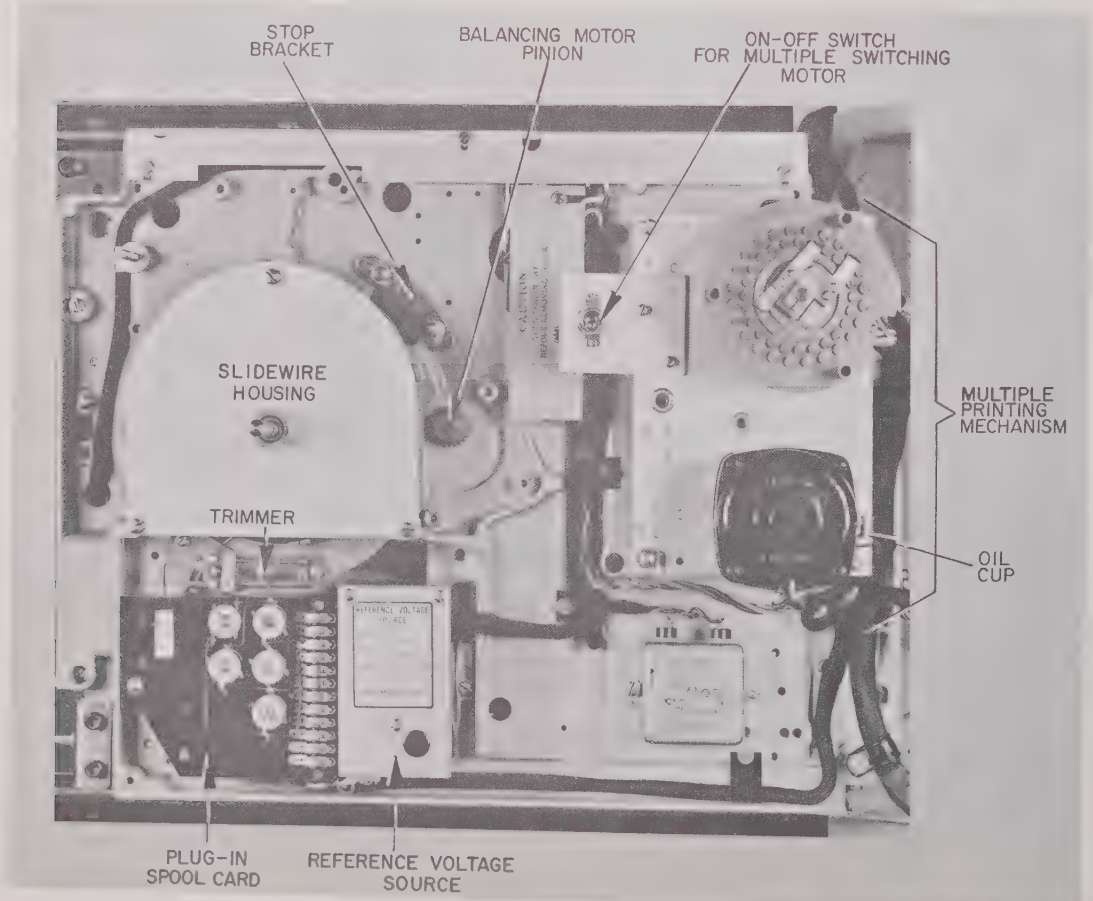

FIGURE 3. BACK OF PANEL, MULTIPLE-POINT DYNAMASTER POTENTIOMETER

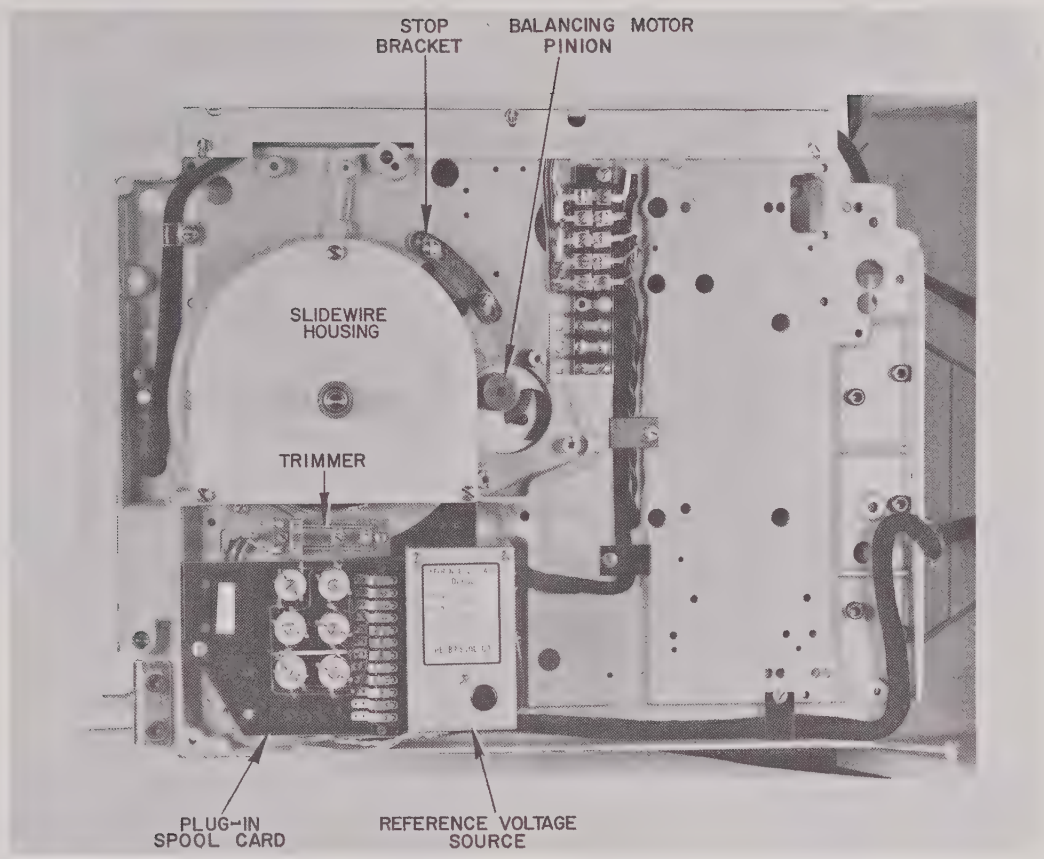

FIGURE 4. BACK OF PANEL, SINGLE-POINT DYNAMASTER POTENTIOMETER

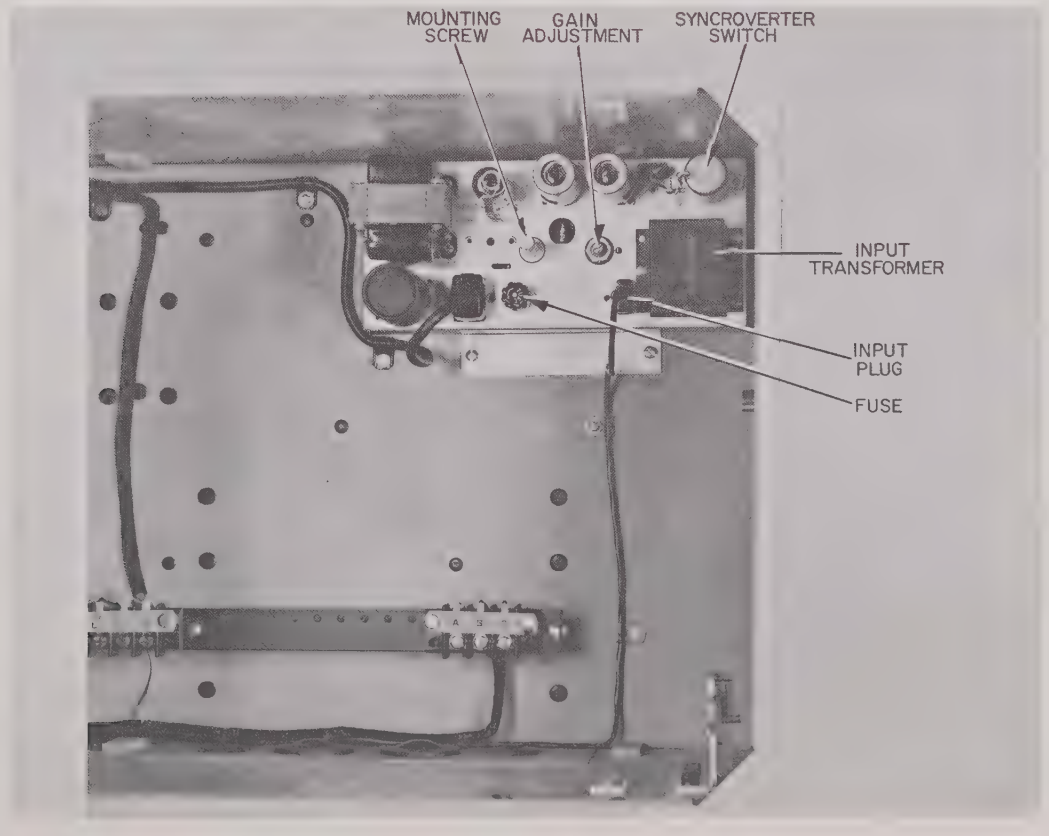

FIGURE 5. INTERIOR OF CASE

measuring element. Thus, recording and indicating of the measured variable is practically instantaneous.

When balance has been restored, the entire bridge remains at rest until another change in the measured variable occurs.

3. The Dynamaster A-C Bridge. The a-c bridge is the same as the d-c bridge except for two items. In the a-c bridge, a bridge transformer is used instead of a d-c power pack and a shorting plug is used in place of the Syncroverter switch.

In an a-c bridge, the measuring element forms one leg of the a-c bridge. A bridge transformer supplies a-c to the bridge circuit. When the resistance of the measuring element changes, current flows in the bridge and a voltage unbalance (error signal) is created. This error signal is fed into the amplifier and amplified to a power level sufficient to operate the balancing motor. The balancing motor adjusts the sliding contact on the slidewire to restore electrical balance in the bridge circuit and simultaneously moves the pen and pointer to record and indicate on the chart or scale, the value of the variable being measured.

This balancing action starts immediately with the slightest change in the resistance of the measuring element. Thus, recording and indicating of the measured quantity are practically instantaneous.

When balance has been restored, the entire bridge remains at rest until another change in the measured variable occurs.

PART II OPERATION

A. Starting the Dynamaster

To start the Dynamaster after it has been completely and correctly wired, simply turn on the instrument on-off switch. Nothing further need be done. If your Dynamaster is equipped with a control unit or other accessory, see separate instructions provided for its operation.

B. Stopping the Dynamaster

To stop the Dynamaster, merely turn off the instrument on-off switch. For a prolonged shut-down, the instrument should be stored in a clean, dry place.

C. Zener Diode Reference Voltage Source (used on Potentiometers only).

The Bristol Zener Diode Reference Voltage Source, used on all d-c potentiometers, is an accurate d-c voltage source with a high degree of stability and reliability. It utilizes Zener diodes as the reference elements in the pre-regulating and output stages of the regulating circuit.

This unit is factory adjusted to produce 1.0190 ±.001 volts across the bridge circuit. No additional adjustment should be required. If it is desired to check the output voltage, it should be done with the load of the bridge circuit disconnected at the reference voltage source output terminal block, and a load of 339.67 ohms substituted across the terminals as equivalent to the proper bridge load.

The check should be made by balancing against a potentiometric test set. If the voltage is not within tolerance, remove the black snap-in plug in the cover below the name plate and adjust the potentiometer to produce the correct output voltage. Replace snap-in plug after any adjustment.

D. Amplifier Gain Adjustment

1. On Single- and Two-pen Recorders. The only time the amplifier gain adjustment need be checked is after changing tubes or doing other service work on the amplifier, and about once every 3 to 6 months thereafter. The reason for the periodic check is because the vacuum tubes age with use. While this check is being made, the measured variable should be at a steady value.

To check amplifier gain, proceed as follows:

Allow amplifier to warm up for at least 2 minutes. Turn the balancing-motor pinion (drive gear) manually to the right

and release it. Then turn pinion to the left and release it. The pen should return quickly to its original position each time. If it does not return to its original position completely and quickly, it indicates that the amplifier gain (or sensitivity) is too low. To increase the gain, turn gain adjusting screw in a clockwise direction. When the gain adjustment has reached its maximum clockwise direction, the amplifier lacks sensitivity and requires new tubes.

There is an optimum position for the gain control. If the gain is too low, the pen will not return quickly to its proper value when the balancing motor is manually shifted off balance. If the gain is too high, the pen may "hunt" (mechanical oscillation of the pen). On some instruments if an abnormal pickup in the external measuring circuit is present, it is possible to turn the gain high enough to overload the amplifier and cause the balancing motor to act sluggishly. This condition can be corrected by reducing the gain (turning gain adjustment counter-clockwise).

2. On Multiple-point Recorders. The gain adjustment on multiple-point recorders is made in the same manner as on single-pen recorders except that the motor on the multiple-switching mechanism must be stopped during this adjustment.

Present instruments are provided with a switch, mounted on the switching mechanism, to cut the power to switching motor.

On instruments without a switch, the power may be broken by disconnecting the gray lead from the switching motor. Be sure to turn off the instrument power supply before disconnecting this lead.

PART III SERVICE

A. Suggested Service Equipment.

1. Stock of Replacement Parts. It is suggested that the following replacement parts be kept in stock. The vacuum tubes listed below are standard types and are available at any radio supply store:

TYPE 6EU7 voltage amplifier tube
TYPE 6BQ5 power amplifier tube
Plug-in-type Electrolytic Filter Capacitor with octal base (10-10-10 mfd. 450 volt)

Note: Electrolytic capacitors deteriorate in storage. Their shelf life should not be over 18 months. Replacement electrolytic capacitors can be kept in usable condition indefinitely by placing them in service in the Dynamaster for an hour or two every six months.

FUSES for amplifier (1/8 ampere Little-fuse Slo-blo).

AMPLIFIER. Where several Dynamasters are in use or where continuous instrument performance is of critical importance, it is recommended that spare replacement amplifiers be kept in stock.

PEN for single-pen recorders

PENS for two-pen recorders

Inked felts for multiple-point recorders

2. Test Equipment

A signal generator, such as Bristol's Dynamaster Part No. C1038, is highly recommended because it provides a quick means for isolating trouble in the detection circuit of the Dynamaster without having to remove the Dynamaster from service or disconnecting the input circuit or the power to the instrument.

The Bristol Dynaprobe test unit is a compact signal generator designed for use with the Bristol Dynamaster.

The Dynaprobe consists of a covered metal box with a 2-foot cable with **test probes** or a test plug and two additional extensions, one with lugs at the end and the other with a female plug. The box has a toggle switch to provide either a 10 millivolt d-c signal or a 30 millivolt a-c signal as required. The output signal is neither regulated or calibrated. The back of the box is fitted with two prongs and two spring type connections to permit plugging the unit into the power terminal block of the Dynamaster.

The Dynaprobe is also equipped with a receptacle to provide 120 volt a.c. for a soldering iron.

An a-c voltmeter or test lamp is required to perform the power-supply check.

An **ohmmeter** is convenient when checking the continuity of the measuring system.

On potentiometer-type instruments, a **potentiometric test set** is required (one with ranges 0 to 150 millivolts and 1.019 volts).

On bridge-type instruments, a set of **test resistance spools** is handy for checking resistance measuring instruments. The Bristol Company manufactures very accurate test resistance spools. Spools may be ordered by the set or singly for any value to fit calibration of instrument. Ordinary variations in room temperature do not affect their accuracy. When ordering spools, specify serial number, curve and check point desired.

B. Systematic Trouble-shooting Procedure

Should the Dynamaster fail in any way, it is first necessary to determine which part is faulty. The following systematic procedure is suggested in order that repairs may be accomplished with a minimum of lost time and expense.

1. Power-supply Check. Using a 150-volt range a-c voltmeter (or test lamp), check for line voltage across instrument power terminals L1 and L2 on back of case, and L1 and L2 terminals on back of hinged panel.

2. Balancing Motor Check

Caution: Always be sure to turn power switch off before shifting the two control winding wires because of the high voltage across terminals M1 and M2.

Turn off instrument power switch. Remove the red and blue control-winding wires from terminals M1 and M2, on rear of hinged panel, and connect them across terminals L1 and L2. Remove black motor lead from L1 and wire a 1-microfarad capacitor in series with it and reconnect to L1. Turn on power switch. The motor should move the pen up or downscale (depending upon phase). Next, turn off power switch and reverse these wires from the control winding. The balancing motor should move the pen in the opposite direction. If the balancing motor fails to move the pen up or downscale with the above test, it could mean that one of the following conditions exist.

1. No power to balancing motor
2. Balancing motor defective
3. Mechanical failure between balancing motor pinion, drive gear and recording pen.

Note: When test has been completed, be sure to return red and blue wires to their original positions (see power circuit wiring diagram) and remove capacitor in series with black wire.

3. Checking Amplifiers

a. With Syncroverter Switch (used on d-c instruments)

With the external power supply switch off, plug Dynaprobe into power supply terminal block on back of instrument case. Set Dynaprobe toggle switch in d-c position. Using extension with polarized female plug, plug extension into input terminals of amplifier. Turn on external power switch. If amplifier is working properly, the balancing motor will move the pen up or downscale (depending upon phase). Reversing the cable plugs on the Dynaprobe will cause the balancing motor to move the pen in the opposite direction.

If the balancing motor does not move the pen up or downscale, disconnect the exitation leads (yellow and brown wires) from the Syncroverter Switch and apply a-c from Dynaprobe to input terminals of amplifier. If instrument works replace Syncroverter Switch.

If instrument does not work after any of the above checks, check fuse in amplifier, replace tubes and filter capacitor in amplifier. If this does not work, replace the amplifier.

b. With plug. (used on a-c bridges).

Checking amplifiers used on a-c bridges is the same as paragraph "a" above except that the Dynaprobe toggle switch should be in the a-c position in all cases and the reference to Syncroverter should be ignored.

4. Measuring System on Potentiometers

The potentiometer type of Dynamaster uses the null-balance potentiometer circuit. The measuring element (such as a thermocouple, magneto, etc.) is wired in series with the potentiometer circuit, Syncroverter contacts and primary winding of the input transformer. This means that

an open circuit anywhere in the measuring circuit, slidewire, Syncroverter contacts or primary winding of the input transformer will produce the same result: no error signal in the circuit and consequently no output from the amplifier to the balancing motor.

Check carefully the particular measuring element used to see that it is functioning correctly. Check particularly the wiring connections at both the measuring element and the instrument. Disconnect the measuring element leads from the instrument and connect them to a potentiometric test set to be sure that the measuring element is producing the voltage required for the existing conditions. See separate instructions covering servicing and checking procedures for the particular measuring element used.

Caution: Never put an ohmmeter across any part of the measuring system without first disconnecting the input leads to the amplifier. The reason for this is that the ohmmeter produces a relatively high current and would damage the Syncroverter contacts.

Assuming that the measuring element and its leads have been eliminated as the source of trouble, proceed as follows:

Check to see that the slidewire brush arm makes good contact with the slidewire (contact pressure is 35-45 grams). Try cleaning slidewire with Bristol cleaning fluid. Allow to dry. Then apply a small amount of Cramolin to slidewire and wipe off excess with a clean lint free cloth.

Caution: If any solvent other than Bristol's cleaning fluid is used to clean slidewire, it must be a type that will not leave a residue or one that attacks varnish.

If the above checks have been performed and the instrument still fails to function, the possible fault may be either an open circuit or a short circuit somewhere in the measuring system. Look for loose or poor connections or possibly a dab of solder that might short out two connections.

5. Measuring System on D-C Bridges. On a d-c bridge, the measuring element is wired so as to form one leg of the bridge. An open circuit anywhere in the bridge will produce an infinite resistance, driving the pen to the top or bottom of the chart depending upon what portion of the bridge is open circuited. If an open circuit is suspected, it can easily be checked with an ohmmeter. See separate instructions covering servicing and checking procedures for the particular measuring element used.

Caution: Never put an ohmmeter across any part of the measuring system without first disconnecting the input leads to the amplifier. The reason for this is that the ohmmeter produces a relatively high current and would damage the Syncroverter contacts.

Assuming that the measuring element and its leads have been eliminated as the source of trouble, proceed as follows:

a. Check output voltage of bridge voltage source (7 to 9 volts d.c.).

b. Check to see that the slidewire brush arm makes good contact with the slidewire (contact pressure is 35-45 grams). Try cleaning slidewire with Bristol's cleaning fluid. Allow to dry. Then apply a small amount of Cramolin to slidewire and wipe off excess with a clean lint free cloth.

c. Look for loose or poor connections or possibly a dab of solder that might short out two connections.

6. Measuring System on A-C Bridge. On an a-c bridge, the measuring element is wired so as to form one leg of the bridge. An open circuit anywhere in the bridge will produce an infinite resistance, driving the pen to the top or bottom of the chart depending upon what portion of the bridge is open circuited. If an open circuit is suspected, it can easily be checked with an ohmmeter. See separate instructions covering servicing and checking procedures for the particular measuring element used.

Assuming that the measuring element and its leads have been eliminated as the source of trouble, proceed as follows:

a. Check for voltage on secondary winding of bridge transformer (7 to 9 volts).

b. Check to see that the slidewire brush arm makes good contact with the slidewire (contact pressure is 35-45 grams). Try cleaning slidewire with Bristol cleaning fluid. Allow to dry. Then apply a small amount of Cramolin to

slidewire and wipe off excess with a clean lint free cloth.

Caution: If any solvent other than Bristol's cleaning fluid is used to clean slidewire, it must be a type that will not leave a residue or one that attacks varnish.

If all of the above checks have been performed and the instrument still fails to function, the possible fault may be either an open circuit or a short circuit somewhere in the measuring system. Look for loose or poor connections or possibly a dab of solder that might short out two connections.

7. The Recording System. The recording system is mechanical. It includes the chart drive and its gear train, chart feed roll, pen or print wheel drive cord and pulleys, etc.

Check the recording system for mechanical troubles, such as loose or binding gears, pulleys and fittings, etc. Move the pen or print wheel up or downscale manually by turning the main drive gear (with power off). It should move freely from one end of the scale to the other.

Feed the chart manually by turning the feed-roll knob counterclockwise. The tension of the feed-roll clutch should be felt, but the chart should feed straight and smooth without tearing or distorting the holes. The pen or print wheel should make a clean, legible record.

See separate instructions on the servicing of the recorder system.

C. Miscellaneous Trouble-shooting Tips

In general, the following symptoms of troubles described below are caused by definite faults.

For all failures not specifically described below, follow the systematic trouble-shooting procedure outlined in Paragraph B, part III.

1. Symptoms: Pen or print wheel remains stationary regardless of changes in the value of the measured variable.

Possible faults:

a. Defective line fuses

b. Power failure

c. Defective amplifier fuse. An amplifier fuse which burns out repeatedly generally indicates a bad rectifier tube or filter capacitor (plug-in capacitor).

d. Defective tube in amplifier

e. Defective filter capacitor

f. Open circuit in measuring element

g. Syncroverter-switch failure

h. Defective balancing motor

2. Symptoms: Pen or print wheel records incorrect values.

Possible faults:

a. Defective measuring element

b. Incorrect gain adjustment

3. Symptoms: Chart does not feed properly.

Possible faults:

a. Chart is not lined up properly

b. Feed-roll clutch is slipping

4. Symptoms: Chart speed is incorrect.

Possible faults:

a. Wrong change gears

b. Defective chart drive motor

c. Frequency of power supply incorrect

D. Checking Calibration

1. On Potentiometers. To check the the calibration of a potentiometer requires the use of a potentiometric test set (one with ranges 0-150 millivolts and 0-to 1.5 volts).

a. Connect potentiometer to input terminals of instrument and turn on instrument power supply. Allow a 10 minute warm up before proceeding with the next step.

b. Set test set for 10% of scale range. Check sensitivity of recorder by moving pen up-scale (by manually turning balancing motor pinion) and allowing instrument to rebalance. Then move pen down-scale and allow instrument to rebalance. Note the dead band. It should be between 0.1 and .05% of full scale. If dead band is greater than 0.1% turn gain control on amplifier clockwise until dead band is correct. If dead band is less than .05%, turn gain control counterclockwise until dead band is correct.

Adjust pen and pointer to read correctly at this point. Do this by loosen-

ing the two screws on the top of the pen carriage which clamps the drive cord to the pen carriage. When pen is correct, tighten screws in clamp.

c. Next, set test set at 80% of scale range. If pen or pointer reads low, loosen slider on trimmer and move slider to left until pen is correct. Tighten slider and check calibration at several more points on scale. If pen or pointer reads high, move slider on trimmer to the right.

2. On Bridge-type Instruments. A bridge-type instrument may be checked with precision test resistors. These precision resistors permit a rapid calibration check at one or more points on the instrument scale. Two resistors are usually sufficient; one representing 10% of the scale range and the other representing 80% of the scale range. To make the check, disconnect the primary element at the terminal block and connect the checking resistor, representing the 10% scale value, in its place. The instrument should read the 10% scale value. If instrument does not record proper value, adjust pen to read correctly. Pen may be adjusted by loosening the two screws on the top of the pen carriage which clamps the drive cord to the pen carriage. When pen reads the correct value, retighten screws in clamp.

Next, connect the resistor, representing the 80% scale value, to the instrument. Instrument should read the 80% scale value. If pen reads low, loosen slider on trimmer and move slider to the left until pen reads correctly. Retighten slider. If pen reads high, move slider on trimmer to the right.

The Bristol Company manufactures very accurate test resistance spools. Spools may be ordered for any value to fit calibration of instrument. When ordering spools, complete with leads and clips, specify from sheet A2833 and give desired resistance or temperature span (F or C) and designate curve and serial number of instrument.

E. Repairs, Correspondence and Shipping

If the Dynamaster cannot be repaired with the information furnished in this instruction, it should be shipped to the nearest Company Branch or Main Factory for repair or replacement. Do not ship instruments to Branch Offices. Be sure to mark your return address plainly.

In all correspondence please mention the instrument model and serial number (as listed on its nameplate) and your repair order number. Address all correspondence to the Bristol Company branch or Main Offices, a list of which is found in all instruction books.

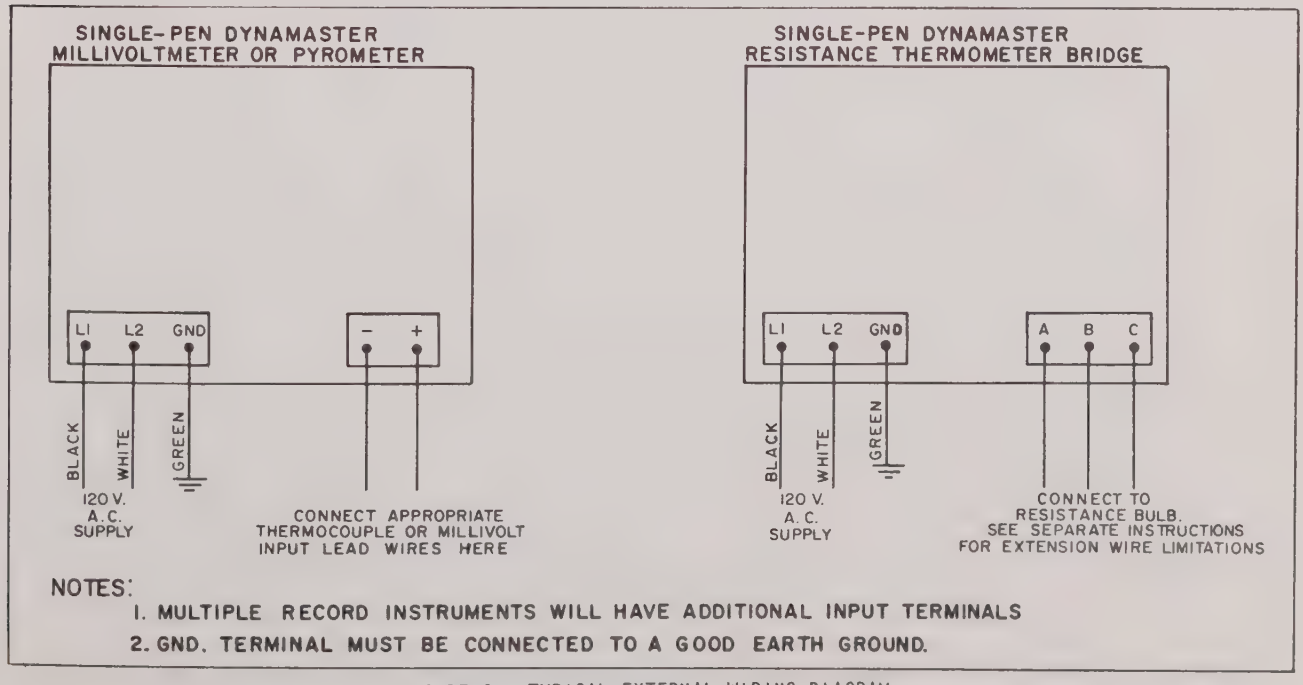

FIGURE 6. TYPICAL EXTERNAL WIRING DIAGRAM.

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INSTRUCTION NO. P12606

SERIES L10 AMPLIFIERS

A. Introduction

This instruction covers the service of the series L10 amplifiers used on Bristol Dynamasters.

Service work on electronic circuits is a specialized technique requiring special test equipment. Only a qualified electronic technician should attempt service inside the amplifier chassis. It is strongly recommended that amplifiers be returned to the Bristol Company for repair if a qualified technician is not available.

B. Test Equipment

A multi-range volt ohmmeter with ranges of 0 to 50 and 0-500 volts d-c, 0 to 4,000 and 0 to 500,000 ohms resistance, voltage sensitivity 20,000 ohms per volt.

MEASURE		CORRECT VOLTAGE	RECOMMENDED CORRECTION	
FROM	TO		IF VOLTAGE IS TOO LOW	IF VOLTAGE IS TOO HIGH
B6	GND	300 ± 30	Check diodes IN5061 No voltage-Replace fuse F1	Replace V_3
B5	GND	295 ± 30	Check diodes IN5061 Replace plug-in capacitor	Replace V_3
B4	GND	260 ± 25	Check diodes IN5061 Replace plug-in capacitor	Replace V_1 or V_2
B3	GND	200 ± 20	Check diodes IN5061 Replace plug-in capacitor	Replace V_1 or V_2
B1-2	GND	160 ± 15	Replace plug-in capacitor Check C19	Replace V_1
K5	GND	270 ± 25	Check voltage at B5	Replace V_3
K4	GND	225 ± 22	Check voltage at K4	Check R19
K3	GND	120 ± 12	Check voltage at K3	Check R15
K2	GND	95 ± 10	Check voltage at K2	Check R7
K1	GND	95 ± 10	Check voltage at K1	Check R3
K5	GND	10 ± 1	Check C14	Check R23
K4	GND	2.75 ± .2	Check C11 and R19	Check R18
K3	GND	1.1 ± .2	Check C9	Check R14
K2	GND	.9 ± .1		Check R6
K1	GND	.9 ± .1	Check C1	Check R2

FIGURE 1. TABLE OF D-C VOLTAGE CHECKS

ACCO BRISTOL DIVISION
WATERBURY, CONNECTICUT 06720

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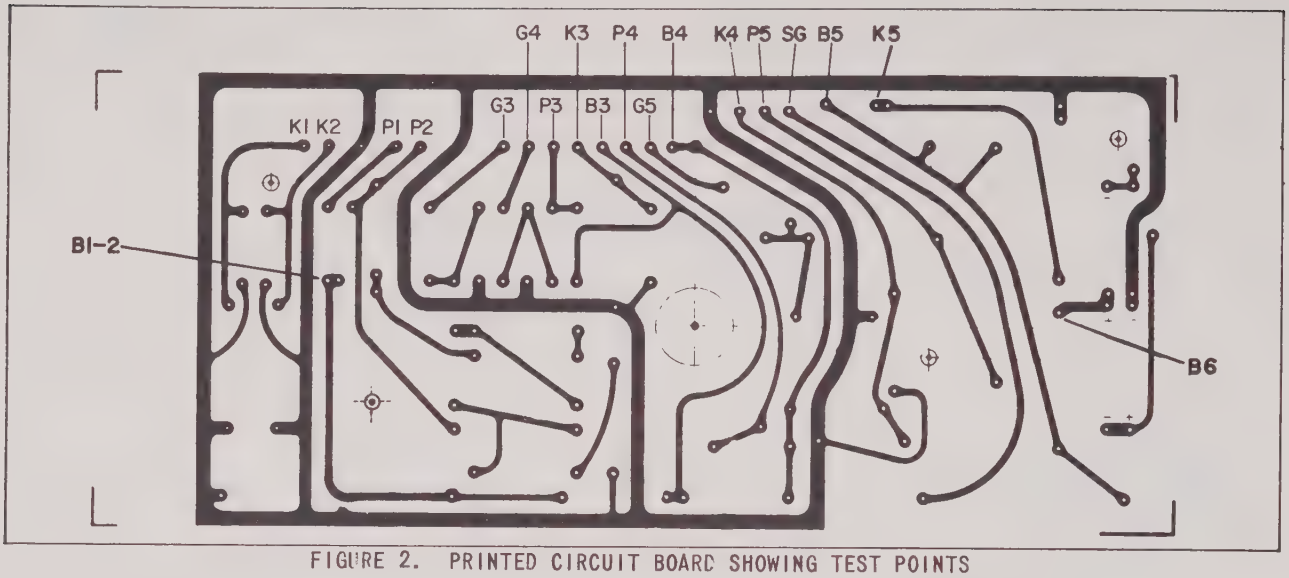

FIGURE 2. PRINTED CIRCUIT BOARD SHOWING TEST POINTS

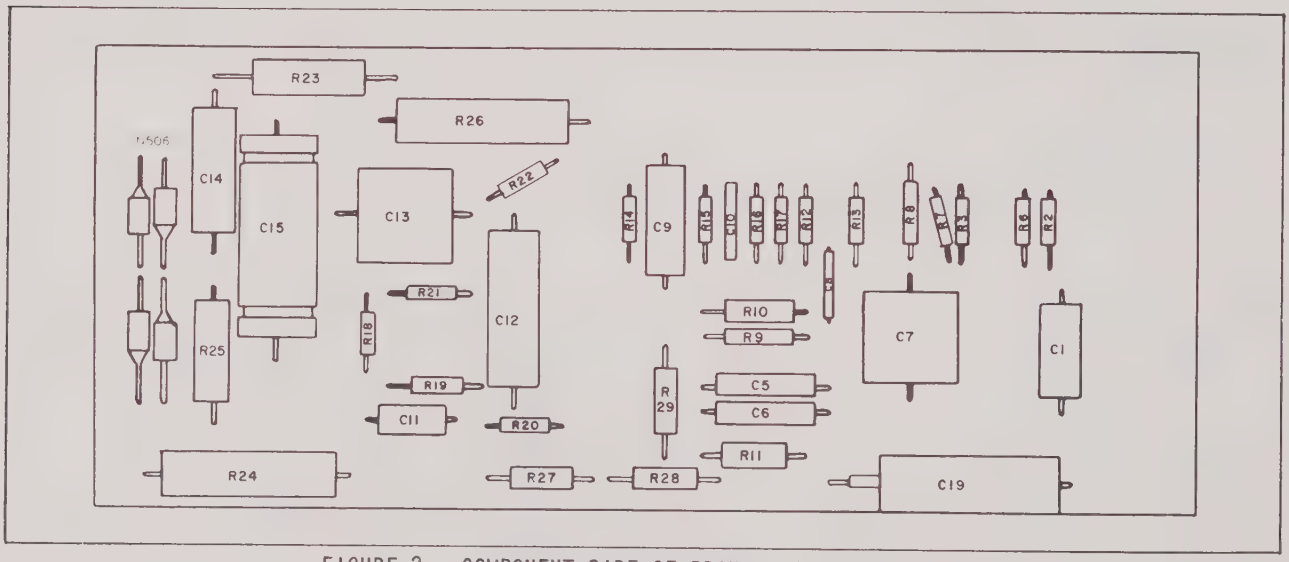

FIGURE 3. COMPONENT SIDE OF PRINTED CIRCUIT BOARD

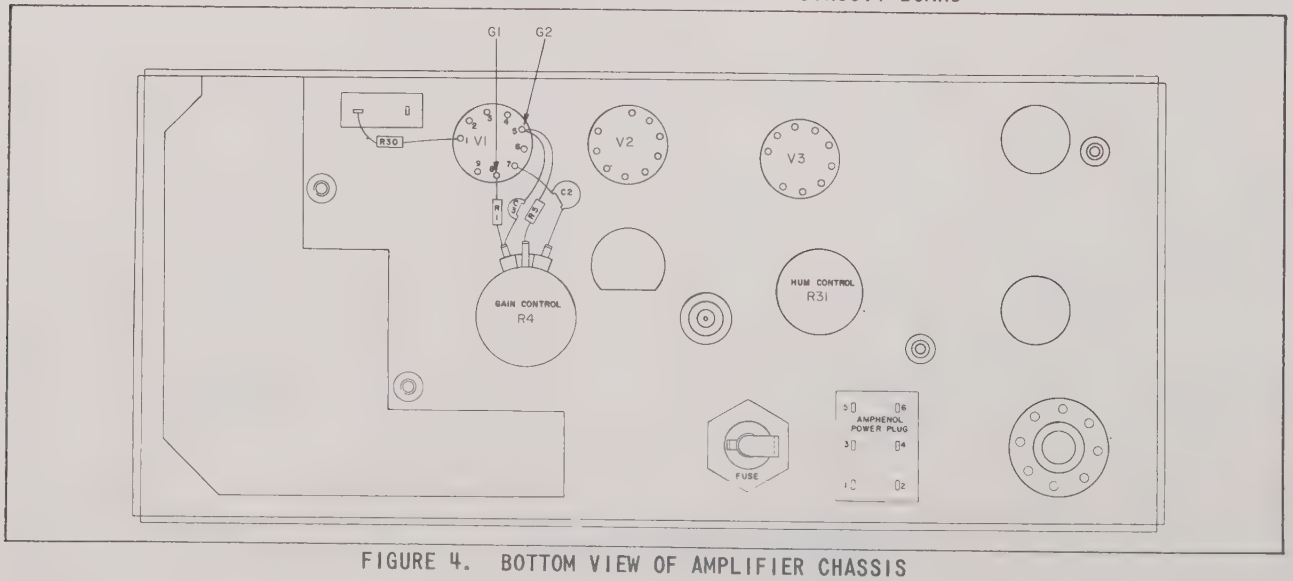

FIGURE 4. BOTTOM VIEW OF AMPLIFIER CHASSIS

C. D-C Voltmeter Check

1. Disconnect all leads to amplifier and remove amplifier from instrument. The amplifier may be removed by loosening the single mounting screw located in the center of the chassis.

2. Connect 117 volt, 60 cycle supply to power plug terminals 5 and 6.

3. Connect a 1000-ohm, 10-watt resistor across output terminals 1 and 2 on power plug. This simulates the motor load.

Caution: Do not operate amplifier without the 1000 ohm 10 watt resistor across the output terminals.

4. Turn gain control to zero (extreme clockwise position).

5. Connect negative lead of voltmeter to the ground connection on the amplifier. Test with the other voltmeter lead at the points listed in the table.

Warning: There are dangerous voltages in the amplifier. Never touch any part with bare hands unless power is off.

The voltages given in the table were taken with a 20,000 ohm per volt meter and with a line voltage of 117 volts. If the line voltage is greater or less than 117 volts, the d-c voltages given in the table will vary proportionally.

Note: Be sure to turn the gain control up again before placing the amplifier back in the instrument. The instrument would be inoperative with the gain in its zero position.

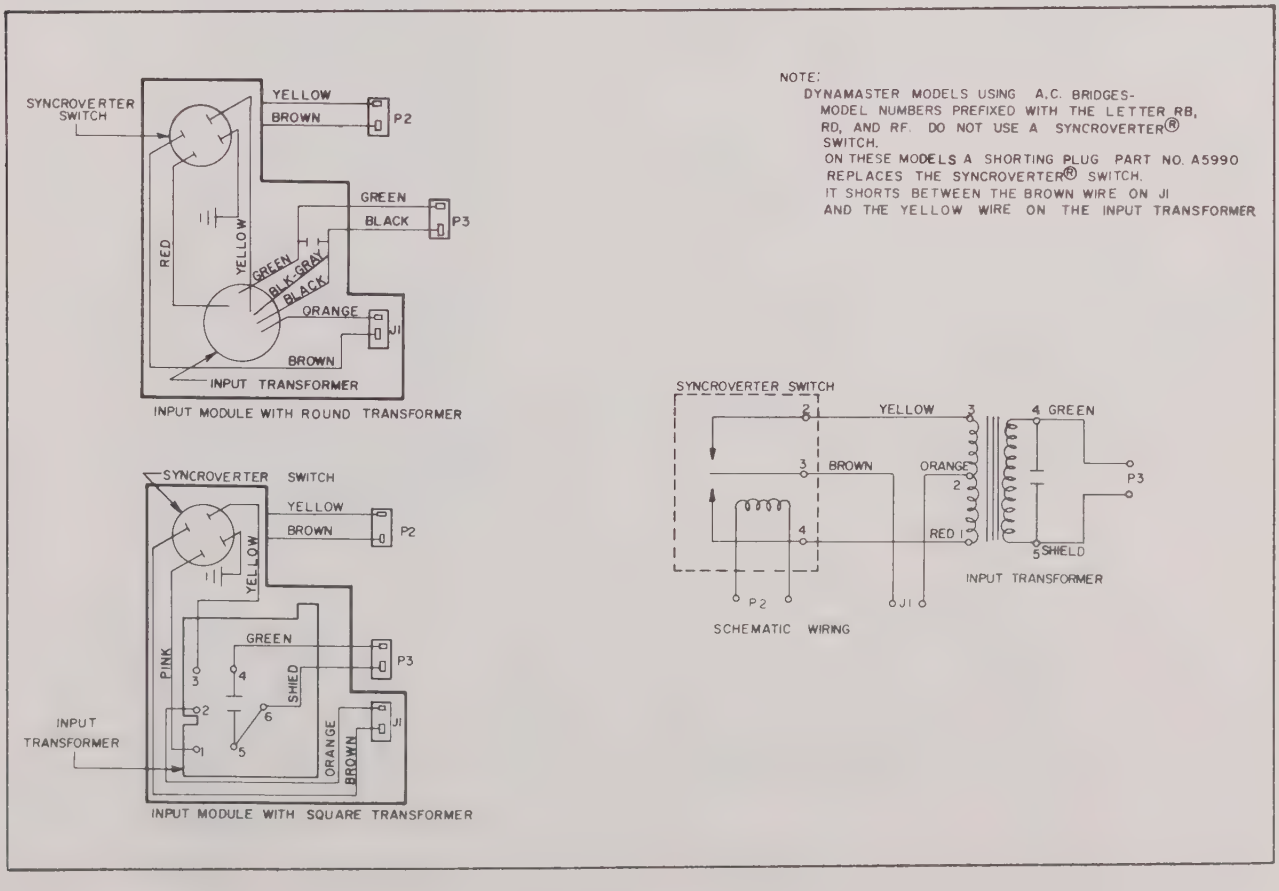

FIGURE 5. INPUT MODULE FOR SERIES L10, L11, L12, L13, AMPLIFIER

MISCELLANEOUS

T2 TRANSFORMER, PRIMARY 117 V.
SECONDARY 0-260, 40 MA.
SECONDARY 6.3 V. 1.5 AMP

DIODES: IN5061

F1 FUSE: LITTLE FUSE 1/8 AMP. SLO BLO.

RESISTORS

R1	RESISTOR 4.7 MEG 1/2 W ±10% TOL.	R16	RESISTOR 470K Ω 1/2 W. ±10% TOL		
R2	RESISTOR 3.3K Ω 1/2 W ±10 % TOL	R17	RESISTOR 1 MEG 1/2 W ±10% TOL		
R3	RESISTOR 220K Ω 1/2 W ±10% TOL	R18	RESISTOR 6.8K Ω 1/2 W. ±5 % TOL		
R4	RESISTOR 1 MEG POT CTS CURVE A	R19	RESISTOR 680K Ω 1 W ±5% TOL.		
R5	RESISTOR 1 MEG. 1/2 W. ±10% TOL.	R20	RESISTOR 470K Ω 1/2 W. ±10% TOL		
R6	RESISTOR 3.3K Ω 1/2 W ±10 % TOL.	R21	RESISTOR 1 MEG. 1/2 W. ±10% TOL		
R7	RESISTOR 220K Ω 1/2 W ±10% TOL	R22	RESISTOR 10K Ω 1/2 W. ±10% TOL		
R8	RESISTOR 300K Ω 1/2 W. ±2 % TOL.	R23	RESISTOR 400 Ω 3 W. ±5 % TOL.		
R9	RESISTOR - 240K Ω 1/2 W ±2% TOL	R24	RESISTOR 10K Ω 7 W ±5% TOL.		
R10	RESISTOR - CALIBRATION 1 W ±10% TOL	R25	RESISTOR 250 Ω 3 W ±5 % TOL.		
R11	RESISTOR 68K Ω 1 W ±10% TOL.	R26	RESISTOR 22K Ω 10 W ±5 % TOL		
R12	RESISTOR 470K Ω 1/2 W. ±10 % TOL.	R27	RESISTOR 56K Ω 1 W ±10% TOL		
R13	RESISTOR 1 MEG. 1/2 W. ±10 % TOL.	R28	RESISTOR 68K Ω 1 W. ±10% TOL.		
R14	RESISTOR 3.3K Ω 1/2 W. ±10 % TOL	R29	RESISTOR - CALIBRATION 1 W. ±10% TOL.		
R15	RESISTOR 220K Ω 1/2 W. ±10% TOL	R30	RESISTOR 33 Ω 3 W ± 5% TOL.		
		R31	RESISTOR 500 Ω POT. C.T.S. SERIES 112.		

CAPACITORS

C1	CAPACITOR 50 MFD 15 V. (ELEC.) $^{+10}_{+150}$ TOL.	C16	CAPACITOR 10 MFD. 450 V. (ELEC.) $^{+10}_{+150}$ % TOL
C2	CAPACITOR .02 MFD. 1000 V. (CER) ±20% TOL.	C17	CAPACITOR 10 MFD. 450 V. (ELEC.) $^{+10}_{+150}$ % TOL.
C3	CAPACITOR 470 MMFD 1000 V. (CER) ±10% TOL.	C18	CAPACITOR 10 MFD. 450 V. (ELEC.) $^{+10}_{+150}$ % TOL.
		C19	CAPACITOR 12 MFD. 250 V. (ELEC.) $^{+10}_{+150}$ % TOL.
C5†	CAPACITOR 0062 MFD. (MICA) ± 5% TOL	*	DENOTES SPRAGUE LITTL LYTICS
C6†	CAPACITOR .0062 MFD. (MICA) ± 5% TOL.		TUBES
C7†	CAPACITOR .0062 MFD. (MICA) ± 5% TOL.	V1	6EU7 MFG. RCA
C8	CAPACITOR .02 MFD. 1000 V. (CER.) ± 20% TOL.	V2	6EU7 MFG. RCA.
C9*	CAPACITOR 50 MFD. 15 V. (ELEC.) $^{+10}_{+150}$ % TOL.	V3	6BQ5
C10	CAPACITOR .02 MFD 1000 V. (CER) ± 20% TOL		
C11*	CAPACITOR 1 MFD. 6 V. (ELEC.) $^{+10}_{+150}$ % TOL	†C5, C6, C7 ARE .0075 MFD FOR 50 HZ AMPLIFIERS	
C12	CAPACITOR .022 MFD. 600 V (PAPER) 10% TOL.		
C13	CAPACITOR .003 MFD 500 V. (MICA) ± 2% TOL.		
C14	CAPACITOR 50 MFD. 50 V (ELEC.) $^{+10}_{+150}$ % TOL.		
C15	CAPACITOR .25 MFD. 600 V. (PAPER) ±20% TOL.		

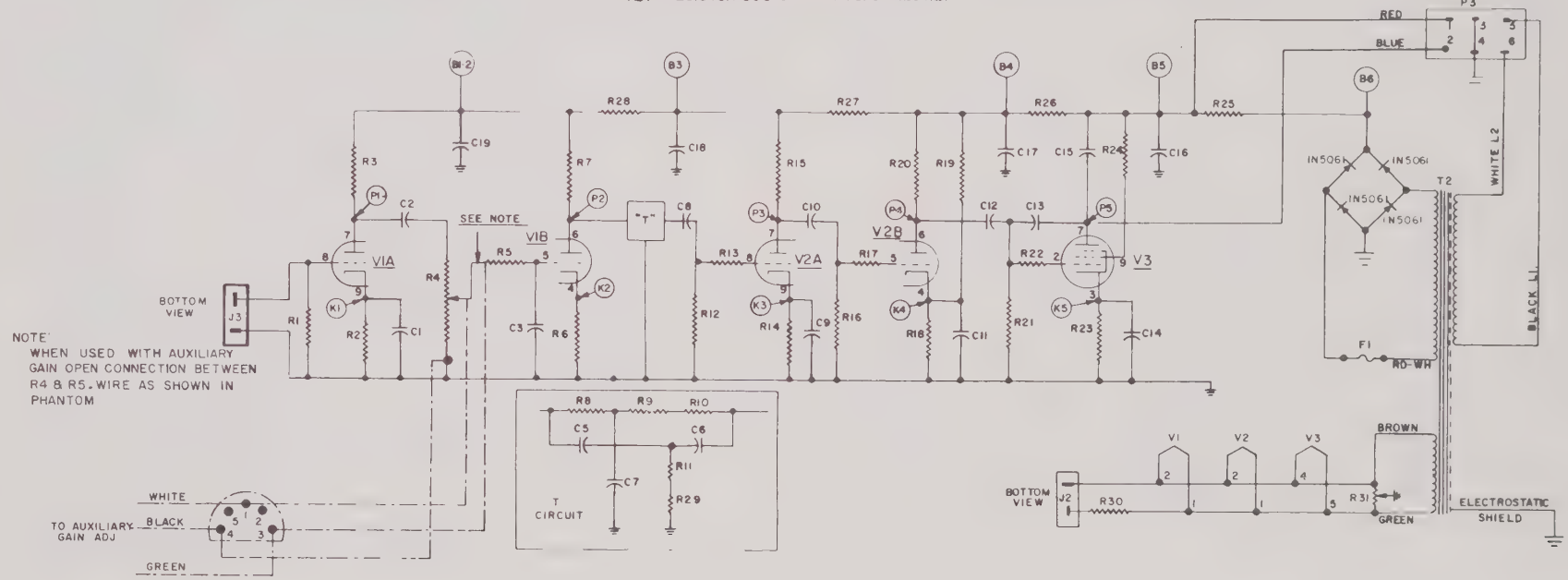

FIGURE 6. SCHEMATIC WIRING OF SERIES L10 AMPLIFIER

INSTRUCTIONS P12500

INSTALLATION & SERVICE OF THERMOCOUPLES, EXTENSION WIRE & PROTECTING TUBES

TABLE OF CONTENTS

	Page No.
PART I. PRINCIPLES	2
A. Thermocouple	2
B. Extension Wire	2
PART II. INSTALLATION	2
A. General	2
1. Thermocouples	2
2. Extension Wire	3
B. Types of Thermocouples	4
1. Iron Constantan	5
2. Copper Constantan	5
3. Chromel Alumel	5
4. Platinum Couples	5
C. Thermocouple Insulation	5
D. Factors Affecting Thermocouple Accuracy	5
1. Location & Mounting of Couple	5
2. Conduction Error	5
3. Corrosion & Poisoning	5
E. Factors Affecting Thermocouple Life	5
1. Temperature	5
2. Corrosion & Poisoning	6
3. Wire Size	6
4. Mechanical Damage	7
F. Specially Calibrated & Certified Thermocouples	7
G. Protecting Tube Temperature Limits	7
1. Metallic Tubes	7
2. Ceramic Tubes	7
PART III. THERMOCOUPLE SERVICE	8
A. Trouble Shooting Procedure	8
1. Resistance check	8
2. Checking a couple in service	8
3. Check by use of Muffle Furnace	8
4. Check by use of a metal bath	8
5. Corrosion & Poisoning	9
B. Correspondence	9

THE BRISTOL COMPANY WATERBURY, CONN. 06720

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PART I PYROMETER PRINCIPLES

A. THERMOCOUPLE PRINCIPLES

If the two junctions in a closed electric circuit made of two dissimilar conductors are at different temperatures, an electromotive force (emf) will be generated, proportional to that temperature difference. In the fundamental thermal circuit (See Fig. 1) the temperatures T_1 and T_2 differ, so an electromotive force develops between the dissimilar metals A and B. An instrument may be used to measure this emf between the pair of junctions. This is the basic circuit and principle of all thermoelectric thermometers.

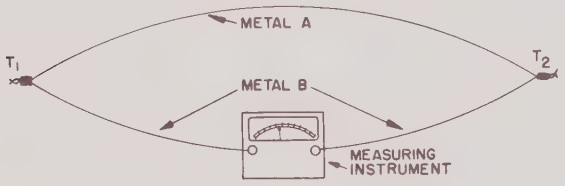

FIG. 1. THE FUNDAMENTAL THERMO-ELECTRIC PYROMETER CIRCUIT.

B. EXTENSION WIRE PRINCIPLES

It must not be overlooked that the measuring junction or "hot" junction is **only one half** the thermocouple and thus the pyrometer is reading not the temperature of this measuring junction but the **temperature difference between the measuring and reference junction.** Therefore, variations in the reference junction affect the instrument reading no less than those in the measuring junction. In the early days the reference or cold end junction was held at constant temperatures by burying it deep in the ground, using a control temperature box and other devices. Today the cold junction temperature is allowed to vary, but mechanical or electrical compensation is introduced into the pyrometer reading. The connections between extension wires and the couple and instrument are also junctions in the pyrometer circuit, whose temperature may vary widely. To prevent introduction of extraneous emf's from such junctions, extension wire must be either of the same metals as the measuring junction itself, or of metals with the same thermoelectric properties. For economics sake, especially with platinum thermocouples, extension leads are made of inexpensive alloys having emf characteristics matching the couples with which they are used.

PART II INSTALLATION

A. GENERAL

Interior temperature of ovens, tanks, baths etc., may vary widely from point to point. Therefore of first importence is the location of the couple so that it acquires the temperature to be measured. A test to determine this correct installation point may be made with a portable thermocouple before the permanent installation is placed. Turbulence of the measured medium at the couple tip should be high if possible to increase heat transfer to the couple. Direct flame with its reducing atmosphere should be avoided. The space between furnace wall and protection tube and other adjacent holes should be cemented to prevent either cooling of the couple by entering cold air or over-heating of the terminal head by escaping hot gases. If possible, install the couple so that the hot end of the tube can be inspected from the furnace door. For temperatures above 1500°F., we recommend that couples and tubes be vertically suspended thru the crown or roof of ovens or furnaces as bending of both metal and ceramic wells is likely at temperatures near their upper limits, if otherwise installed.

1. Thermocouple Installation (see drawings of typical installations).

The entire couple junction should be inserted at least 10 diameters of the protecting tube beyond the inside surface of the furnace or beneath the surface of a liquid or molten metal.

Thermocouple should be preheated before installation in a hot furnace to avoid breakage of the porcelain insulators due to thermal shock. A thermocouple which is to be permanently installed should be mounted firmly with proper support. It must be protected from mechanical injury and should not be subjected to severe jarring. Never locate a thermocouple in a furnace or oven where it will

be subjected to direct flame impingement. The life of the protecting tube will be materially shortened and the temperature readings will not be representative of the normal furnace atmosphere.

Once a thermocouple is installed in a furnace it should not be removed or disturbed. If it is desired to check the calibration of the couple, a second couple should be inserted in the furnace so that the tips touch each other. If a couple is removed from a furnace and used elsewhere, the depth of immersion may differ and the heated portion of the wire will be in a different temperature gradient, causing an error. It is better to obtain a new couple rather than transfer an old one to another application.

Couples used in liquids or in molten metals, pots, kettles, etc., are best mounted so that they may be conveniently withdrawn at any time for inspection or testing. Suspension of such couples by chains, pulleys, and counter balances is recommended so that they may be quickly removed while charging the pots. No metallic protecting tube will indefinitely resist the corrosive action of molten aluminum or aluminum alloys. Refractory tubes are too liable to breakage, on the other hand, to be practical. Many foundries follow the practice, therefore, of daily painting metallic tubes with a thick white wash solution. Paints of sodium silicate and silicon carbide mixtures are also used. If necessary tubes of the cold extension type as illustrated in Fig. 13 or the angle type Fig. 12 should be used so that the terminal head may be located in a cool accessible spot for testing and inspection of the couple and connection.

Distortion of couple junction by rolling, twisting or hammering will cause calibration changes due to molecular rearrangement in the couple metal. The electrical welding process employed by The Bristol Company in making thermocouple junctions avoids mechanical working and substantially reduces this source of calibration error. Calibration is also affected by excess vibration, and the frequency and degree of heating and cooling.

2. Extension Wire Installation

Connect the extension wires to the thermocouple by means of the terminals provided, the other end of the extension going to the instrument binding posts. When connecting a thermocouple and extension to an instrument the polarity must be strictly observed i.e.; positive (+) to positive and negative (-) to negative. (See Figure 3).

CAUTION: Always use extension wires specifically designed for the kind of couple being used. Never use plain copper wires or extension wires intended for another kind of thermocouple.

For all permanent installations, we recommend that a covered terminal head be used with all extension wires contained in conduit, which connects directly into rotary switches, instrument cases and the thermocouple head. If flexibility is necessary use a flexible armored extension wire.

CAUTION: Extension wires should never be installed parallel to or crossing within 12 inches of an a-c power line and all conduit should be grounded to prevent induced currents. All splices in extension wires should be carefully soldered and carefully taped.

CONDUIT SIZE (INCHES)	APPROXIMATE NUMBER OF PLASTIC AND BRAID INSULATED DUPLEX ENTENSION WIRES ACCOMODATED BY CONDUIT.				
	#8	#10	#12	#14	#16
1/2	1	1	1	2	4
3/4	2	2	3	4	6
1	3	4	5	6	9
1-1/4	6	7	8	10	20
1-1/2	9	12	13	15	26

FIG. 2. A GUIDE TO THE SIZE OF CONDUIT FOR EXTENSION WIRE.

THERMOCOUPLE		EXTENSION WIRE		COLOR CODE	
ISA CODE	FORMER CODE	CODE	MATERIAL	INDIVIDUAL	OVERALL
J	IC	JX	+ IRON - CONSTANTAN	WHITE RED	BLACK
T	24B	TX	+ COPPER - CONSTANTAN	BLUE RED	BLACK
K	25H	VX	+ COPPER - CONSTANTAN	BROWN RED	RED
K	25H	KX	+ CHROMEL - ALUMEL	YELLOW RED	YELLOW
S	27	SX	+ COPPER - SPECIAL ALLOY	BLACK RED	GREEN
R	32	SX	+ COPPER - SPECIAL ALLOY	BLACK RED	GREEN
E	H	EX	+ CHROMEL - CONSTANTAN	PURPLE RED	BROWN

FIGURE 3. COLOR CODE OF EXTENSION WIRES.

a. Installation Millivoltmeter Pyrometers. Millivoltmeter type pyrometers are calibrated for a definite external resistance (sometimes called C + L which is the total resistance of the thermocouple and extension wire. The external resistance is marked on the scale plate of the instrument. Standards for current models call for 2 ohms external resistance unless order specifies otherwise. Uncalibrated extension wire will result in an error of less than 1% on these instruments if extension lengths do not exceed 30 ft. of duplex no. 14 wire. Therefore, in most cases, uncalibrated extension can be used with all modern high resistance millivoltmeter pyrometers. Exceptions to this are when extension wires are long, in which case calibrating for a higher external resistance should be specified or when exceptional accuracy is required, in which case the extension wire should be calibrated to match the instrument. The internal resistance of the instrument is marked on the scale plate. This resistance is measured across the binding posts.

CAUTION: Never use an ohmmeter to measure the resistance of a millivoltmeter movement. Use a potentiometer type test set.

A high resistance millivoltmeter pyrometer has an internal resistance above 150 ohms. A low resistance instrument has an internal resistance of less than 50 ohms.

Any change in external resistance will cause a much more serious error in the instrument having a low internal resistance than one with a high internal resistance. Changes in the line and couple resistance of as much as 2 or 3 ohms are not uncommon in practice and may be caused by oxidation of the thermocouple wires, poor contacts or connections, variable depth of immersion of the thermocouple, temperature variations in the extension wire and structural faults in the wire.

b. Installation Potentiometer Pyrometer. It is unnecessary to calibrate extension wire when used with a potentiometer type pyrometer. The reason for this is that when the instrument is at balance, the instrument draws no appreciable current and therefore produces no measurable voltage drop in the extension wires.

B. THERMOCOUPLE TYPES

Metals for thermocouples are selected to give the largest possible emf, which increases with an almost linear relationship to temperature, while possessing resistance to melting, corrosion and changes in emf characteristics during use. While platinum, which was used for most early couples, possesses all the above desirable qualities, its high cost makes very desirable the substitution of less expensive "base metal" thermocouples. Therefore in 1905 The Bristol Company developed the first practical base metal thermocouple. Since then many variations of base metal thermocouples have been developed and by continued research the number of base metal thermocouples now in use has been reduced to three.

1. **The iron constantan**, "J" couple with positive wire of iron and negative wire of constantan, an alloy of approximately 55% copper and 45% nickel is recommended for reducing atmospheres. The operating range for the J couple is 1600°F maximum for the largest wire size and lower for the smaller sizes. See Figure 4.

Before the standard J couple had been adopted by the pyrometer industry, The Bristol Company made thermocouples of pure iron and of constantan of slightly different emf characteristics, known as the "18B" curve" which can still be furnished on order in any type or form, as replacement for existing instruments.

2. **The copper constantan couple** (Bristol T Curve or the Adams Curve per NBS RP1080), with positive wire of copper and negative wire of constantan is recommended for use in mildly oxidizing and reducing atmospheres thru 650°F, applications where moisture is present and for low temperature work down to -300°F. This couple is recommended for temperatures below 400°F or 200°C because its emf curve is more linear than the J couple in this range.

3. **The Chromel-Alumel Couple** (Bristol K curve) with positive wire of chromel (an alloy of approximately 90% Ni and 10% Cr.) and the negative wire of alumel (an alloy of approximately 95% Ni, 5% Al., Mn and Si) is recommended for use in clean oxidizing atmospheres. Because it gives high emf temperature curves and its high nickel content provides oxidation resistance, the K couple is the most practical and widely used.

4. **Platinum Thermocouples.** Two types of noble metal couples are in use, first the LeChatelier, with negative wire of pure platinum and positive wire of 90% platinum and 10% rhodium (Bristol S Curve), second the "87-13 type thermocouple (Bristol R Curve). Because the 90-10 platinum rhodium-platinum couple is used in defining the international temperature scale and by the National Bureau of Standards, it is offered as the standard by The Bristol Company. However we can furnish the 87-13 type platinum couple on order.

C. THERMOCOUPLE INSULATION

Three kinds of insulation can be supplied with Bristol Thermocouples, the asbestos, procelain and glass fibre. Asbestos insulation is molded on bare wires. Porcelain insulation is recommended for use above 1600°F or 850°C as asbestos insulation becomes brittle above this temperature. Asbestos insulation is frequently preferred with angle type thermocouples for ease in replacement of elements which can be bent as required on the job. Glass fibre may be used up to 900°F.

D. FACTORS AFFECTING THERMOCOUPLE ACCURACY

1. **Location** - see general installation instructions and installation illustrations.

2. **Conduction Error** - Heat conduction away from the measuring junction along the protection tube and couple wires will cause serious errors in temperature reading unless the entire couple junction is inserted at least 10 diameters of the protection tube beyond the inside surface of the furnace or beneath the surface of a liquid or of molten metal. It may be concluded that immersion is sufficient to achieve this accuracy, if no noticeable change in temperature reading occurs upon withdrawing the couple 1 inch from its protection tube. With very high temperatures, to prevent couple melting, only partial immersion may be used. For examples see Fig. 13. Furnace temperature variations may thus be measured and even heat control thus accomplished, but obviously with partial immersion of the thermocouple, true temperatures are not obtained. Many suggested types of installation are shown further on in this book.

3. **Corrosion & Poisoning.** Accuracy of thermocouples will be rapidly and seriously destroyed by poisoning, alloying or contamination of the couple metal. See paragraph on corrosion and poisoning in section under factors affecting thermocouple life.

E. FACTORS AFFECTING THERMOCOUPLE LIFE

In general the following four factors affect the life of the thermocouple in the order given and should be so considered when selecting a couple.

1. **Temperature.** The following table gives a conservative guide to minimum and maximum temperature of the standard type couples.

Types of Thermocouple	Temperature Ranges	
	°C	°F
PLATINUM-PLATINUM RHODIUM S OR R CURVE		
#24 AWG (20 Mill)	0-1482	0-2700
CHROMEL-ALUMEL (K)		
#8 AWG	0-1262	0-2300
#14 AWG	0-1093	0-2000
#20 AWG	0-982	0-1800
IRON CONSTANTAN (J)		
#8 AWG	0-760	0-1400
#14 AWG	0-593	0-1100
#20 AWG	0-482	0-900
COPPER-CONSTANTAN (T)		
#14 & #20 AWG	-183 to +345	-300 to +650
CHROMEL-CONSTANTAN (E)	-100 to +900	-300 to +1800

FIGURE 4. MAXIMUM CONTINUOUS TEMPERATURE LIMITS (COUPLE IN WELL).

For temperatures above 2650°F or 1450°C the radiation type of thermocouple is recommended.

2. Corrosion and Poisoning. The oxidizing and reducing effects of air and of furnace atmosphere, corrosion by chemicals, fumes etc. are very common causes for couple failure. Should there be any question whether an atmosphere is oxidizing or reducing a simple test can be performed. See Part III Service.

a. Iron constantan (J) thermocouples should be used in a reducing atmosphere. The life of both the iron and constantan legs will remain substantially the same, except in oxidizing atmospheres. In this case the iron will deteriorate more rapidly than the constantan.

b. Copper constantan (T) thermocouples withstand oxidation in temperatures up to 650°F. Beyond this temperature the copper leg commences to oxidize rapidly.

c. Chromel-Alumel (K) thermocouples should be used in clean oxidizing atmospheres. Sulphur in an atmosphere will rapidly contaminate a chromel-alumel thermocouple causing calibration errors and rapid failure. Where it is known there is a high sulphur content such as found in burning Bunker C oil or natural gas, special protection wells or tubes should be ordered for the thermocouples. In using powdered coal as a source of heat for certain high temperature applications, the atmosphere may contain sulphur and carbon in their many states. Unless adequate protection is provided, the couple will undergo extremely rapid deterioration known as "green rot". Further, the protection tubes used for chromel-alumel thermocouples should be clean and free of any traces of core sand, oil or other organic materials that form carbon and reducing agents at high temperatures. Where doubt exists concerning the cleanliness of such a tube it should be heated in a furnace at or near 1500°F for several hours to burn off any organic matter present. The choice of insulators used on chromel-alumel thermocouples may also affect the life of the thermocouple. Presence of the so called "alkaline earths" such as sodium and phosphorous would contaminate a chromel-alumel thermocouple, cause a calibration shift and shortened life. Insulators furnished by The Bristol Company are cleaned to remove contaminating matter.

d. Platinum Rhodium-Platinum (S or R) Thermocouples in general have a high resistance to oxidation and corrosion. However, hydrogen, carbon and many metal vapors found in furnace atmospheres will seriously contaminate a platinum rhodium platinum thermocouple. Therefore a gas tight, non-metallic protection tube should be used.

3. Couple Wire Size. Couples made of large wire, such as No. 8 to No. 14 resist corrosion far longer than the smaller sizes but the smaller sizes are more responsive to temperature changes. Therefore in choosing the wire size for a given thermocouple, a compromise between responsiveness and life of the couple must be made based upon the requirements of the particular application.

Platinum rhodium and platinum thermocouple wire comes only in the #24 AWG size. Other couple materials are available in several sizes.

4. Mechanical Damage. Distortion of couple junction by rolling twisting or hammering will cause calibration changes due to molecular rearrangement in the couple metal. Calibration is also affected by excess vibration and the frequency and degree of heating and cooling. Obviously, the only way that these conditions can be avoided is by the proper selection of couple location and protection tubes.

F. CALIBRATED THERMOCOUPLES

Any Bristol thermocouple can be supplied, at an extra charge, either with an individual calibration curve, made in Bristol's laboratory by precision comparison against National Bureau of Standards certified couples or can be supplied with a certificate of check by the National Bureau of Standards itself. In ordering such calibrated thermocouples, be sure to specify over what temperature range the greatest accuracy is desired. We recommend that all thermocouples to be used as standards or for checking work, be ordered with one of the two above calibration curves supplied.

NOTE: When ordering certified selected thermocouples your order must read 12" greater than the length you desire. (Applies only to base metal couples).

G. PROTECTING TUBES

Thermocouples must not be immersed, without the protection of a well or protecting tube, in fluids or gases of a corrosive or erosive nature. The function of the protecting tube is to protect the couple wire against mechanical damage and corrosive or contaminating atmospheres. Protecting tube materials are chosen for their ability to withstand at high temperatures, mechanical shock and stress, sudden temperature changes, oxidation or reduction, chemical corrosion and metallic amalgamation, while at the same time providing high thermoconductivity and low porosity to gases. Since no one material possesses all these qualities it is necessary to choose a tube to suit the installation.

1. Metallic Tubes - A conservative guide for the maximum safe temperatures for various metal tubes or wells is given in Figure 5.

Metallic tubes are usually sufficient protection for base metal couples, although a single Mullite tube is frequently used with chromel-alumel couples between 2000 & 2400°F.

2. Ceramic tubes. Due to its tendency to contamination, the platinum couple cannot be used in metallic tubes but should be protected by a suitable gas tight refractory protection tube such as a mullite or fused quartz. As the refractory tubes are fragile, a secondary tube of metal or ceramic depending upon the temperature is often used outside this first or primary tube to provide mechanical protection.

TYPE OF TUBE	RECOMMENDED MAXIMUM TEMPERATURE	
	°C	°F
Seamless Steel	550	1000
Wrought iron	700	1300
Cast iron	700	1300
Chrome iron (28%)	1100	2000
Stainless steel (18% cr. -8% Ni.)	850	1600
Nichrome	1100	2000
Thermalloy (cast steel with 24 cr. 12 Ni)	1200	2200
Chromax (cast steel with 18 cr. 35 Ni)	1100	2000
Misco B (drilled steel 24 cr. 12 Ni)	1100	2000
Nickel	1100	2000
Inconel (79.5 Ni., 13 cr., 6 Fe)		
For Furnace	1260	2300
For lead bath	980	1800

FIG. 5. RECOMMENDED MAXIMUM OPERATING TEMPERATURES OF METAL PROTECTION TUBES.

PART III THERMOCOUPLE SERVICE

The accuracy of a thermocouple will depend on temperatures being measured, oxidation, contamination, the care with which a couple is made and the alloys used for the couple. As the accuracy of a thermocouple will become progressively less as the couple deteriorates it is advisable to test couples at intervals varying from once a week to once every three months, depending on the service.

Iron constantan couples change very little from time of installation to end of couple life. Chromel-Alumel couples change continuously with age.

A. TROUBLE SHOOTING PROCEDURE

One of the most frequent causes of pyrometer trouble is due to poor connections between thermocouples and instrument. When a pyrometer fails to indicate proper temperature first check connections between extension wires and instrument and between extension wires and couple. Quite frequently when first installing or replacing a couple or extension wire the connections at the couple are reversed and an error results.

1. Resistance Check. Most present day millivoltmeter instruments are high resistance movements. The external resistance on these movements is usually 2 ohms. Older type movements were of the low resistance type with an internal resistance of 100 ohms or less and usually have a calibrated extension wire with a resistance of 10 to 15 ohms.

Changes in the external resistance of as much as 2 or 3 ohms are not uncommon in practice and may be caused by oxidation of the thermocouple wire, poor connections, variable depth of immersion of the thermocouple, temperature variations in the extension wire and structural faults in the wire.

When making a resistance check disconnect extension wires from instrument. Hook up an ohmmeter across ends of extension wire. If ohmmeter reading is considerably higher than the external resistance value marked on scale plate of instrument, check resistance at the thermocouple itself. If resistance is high at couple the fault lies in the couple. If resistance is OK at couple but high at instrument end of extension wires the fault is in the extension wires.

CAUTION: Never use an ohmmeter to check the internal resistance of a Millivoltmeter type instrument. Use only a potentiometer type test set.

2. Checking a couple in service. This method is used only when a quick test is necessary and where accuracy is not important. It may be done in one of several ways.

a. Inserting test couple in a test hole near the permanent couples. It is important to duplicate the conditions of the permanent couple as closely as possible and the test couple should have the same type of protecting tube. Readings of the two couples may then be compared.

b. Inserting test couple in same protecting tube as permanent couple if there is room and comparing their readings.

c. Alternately inserting the test couple and permanent couple in same hole. Satisfactory results can only be obtained by this method when the furnace temperature is reasonably constant.

3. Check by use of Muffle Furnace. One of the most desirable methods of checking a thermocouple is by means of a small muffle furnace. Remove couple to be checked from its protecting tube and tie the hot junction to the hot junction of a test couple with asbestos string. Insert couples in the furnace and bring furnace up to a constant temperature within the temperature range in which the couple is intended to operate. When the two couples have reached a constant temperature the emf of each may be read on a test instrument connected to the couples thru a switch which permits couple to be alternately connected to test instrument.

4. Check by use of a Metal Bath. This method is satisfactory for many industrial users but is not as accurate as the muffle furnace method. Equipment includes an iron pot filled with lead or tin, covered with graphite and heated by means of a gas or electric furnace. The thermocouples to be tested, including the standard, are inserted in an iron protecting tube closed at one end, and immersed in the molten bath. Read-

ings are taken when a temperature equilibrium is reached. The practical temperature range is between 600 and 1800°F. Couples should be immersed in the bath to a depth of at least 12 inches.

5. Corrosion and Poisoning. The oxidizing and reducing effects of air and of furnace atmosphere, corrosion by chemicals, fumes etc. are very common causes for couple failure. Should there be any question whether an atmosphere is oxidizing or reducing, a simple test can be performed. Cupric oxide may be used as an indicator, provided it will not react dangerously with the application. If the cupric oxide remains black, the atmosphere in which it was placed is oxidizing. If it turns to some shade of red, the atmosphere is reducing. When the cupric oxide is placed in a protecting tube with a thermocouple and allowed to operate at high temperature, reduction of the cupric oxide may produce molten copper that will cause the thermocouple to stick to the protection tube when the assembly is withdrawn and allowed to cool. This would indicate that reducing gases have leaked thru the tube.

6. The following is a list of desirable checking equipment.

1. Potentiometer Type Test Set.
2. Ohmmeter.
3. Standard platinum couple with protecting tube.
4. Standard base metal thermocouple.
5. Electric muffle furnace or metal bath.
6. Temperature-Millivolt equivalent tables. (Included with all pyrometers).

B. CORRESPONDENCE AND INFORMATION

If difficulties arise or information is needed, write to the nearest Bristol Company branch office stating the nature of the problem and all pertinent data. For all replacements, supplies and information, it is essential to give the model and serial number of the instrument.

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SUGGESTED METHODS OF THERMOCOUPLE INSTALLATION

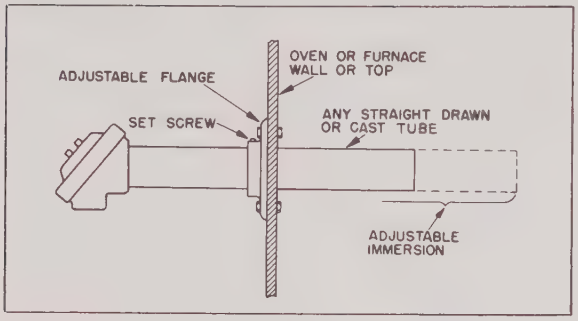

FIG. 6. SHEET METAL OVEN, FURNACE FOR DUCT WALL WITH COUPLE MOUNTED WITH ADJUSTABLE FLANGE.

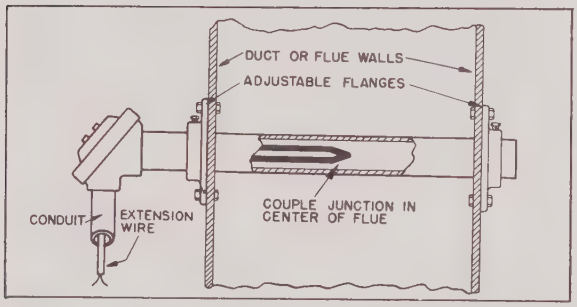

FIG. 7. BOILER BREECHING, COAL DRYER FLUE OR DUCT WITH COUPLE USING ANY STRAIGHT WELL MOUNTED FROM SIDE TO SIDE OF DUCT WITH TWO ADJUSTABLE FLANGES.

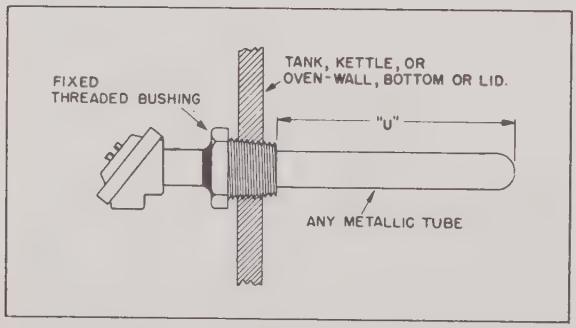

FIG. 8. TANK, KETTLE OR OVEN WITH ANY METALLIC WELL MOUNTED BY A FIXED THREADED BUSHING.

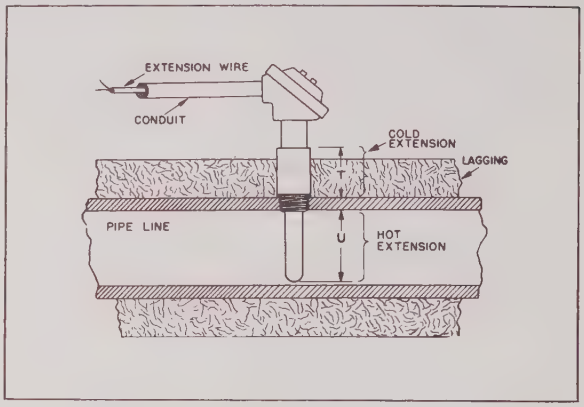

FIG. 9. HIGH PRESSURE STEAM, OIL, GAS, ETC., PIPE LINE WITH THERMOCOUPLE PROVIDED WITH EXTENSION "F" TO PASS THROUGH LAGGING.

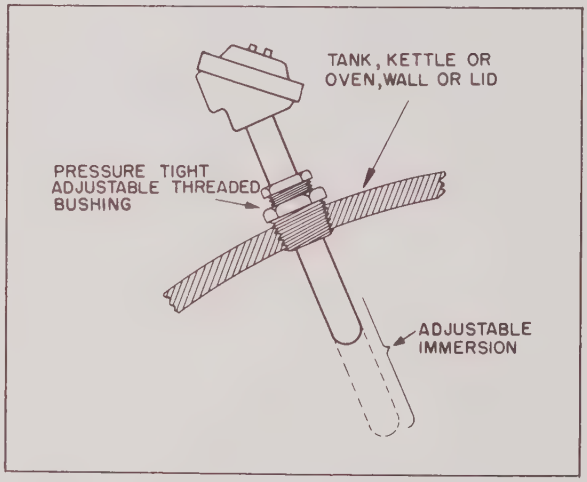

FIG. 10. TANK, KETTLE, PIPE OR OVEN WITH THERMOCOUPLE MOUNTED WITH A PRESSURE AND GAS TIGHT ADJUSTABLE THREADED BUSHING.

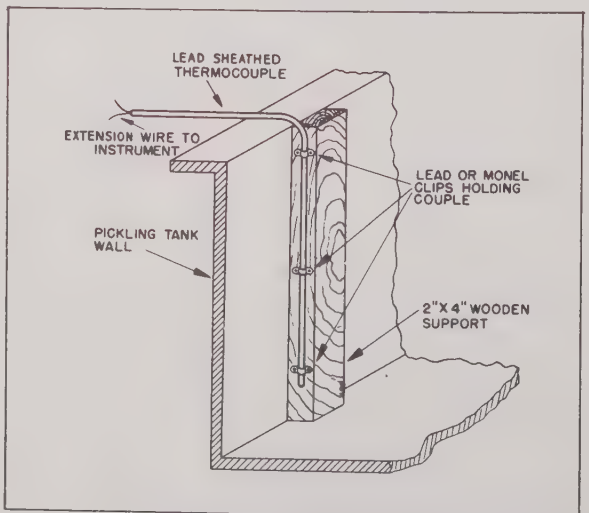

FIG. 11. PICKLING, PLATING OR ACID TANK SHOWING SUGGESTED MEANS OF MOUNTING LEAD SHEATHED REPARABLE THERMOCOUPLE.

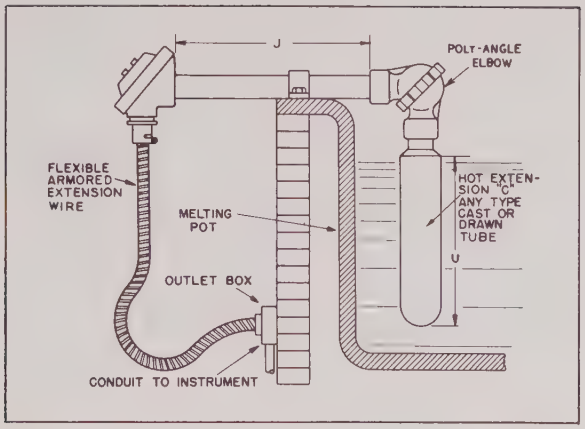

FIG. 12. POT OR KETTLE FOR ALUMINUM, DIECAST METAL, STEREOTYPE, GALVANIZING, MOLTEN SALT BATHS WITH ANGLE TYPE COUPLE. FLEXIBLE ARMORED EXTENSION WIRE PERMITS REMOVAL OF COUPLE FOR CHARGING POT, COUPLE INSPECTION AND WHITEWASHING OF WELL.

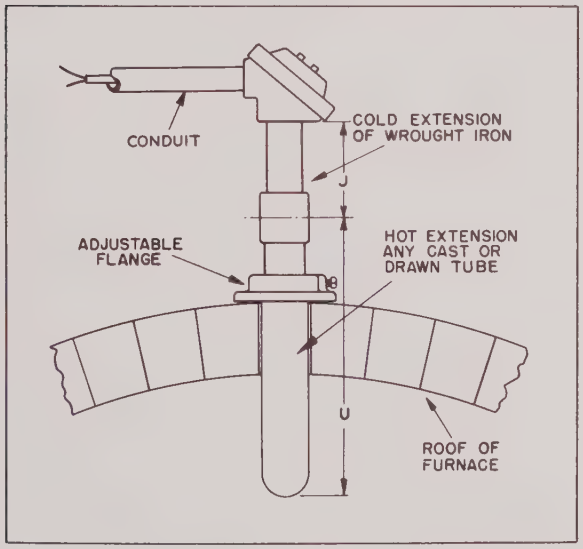

FIG. 13. MUFFLE, HEAT TREATING OR HARDENING FURNACE WITH HOT AND COLD EXTENSION TYPE COUPLE MOUNTED WITH AN ADJUSTABLE FLANGE.

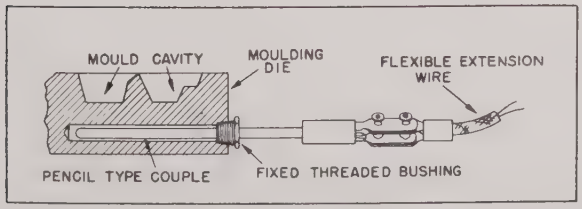

FIG. 16. MOULDING TEMPERATURES OF DIES IN PLATEN PRESS PLASTIC MOULDING TAKEN WITH PENCIL TYPE COUPLE MOUNTED WITH FIXED THREADED BUSHING.

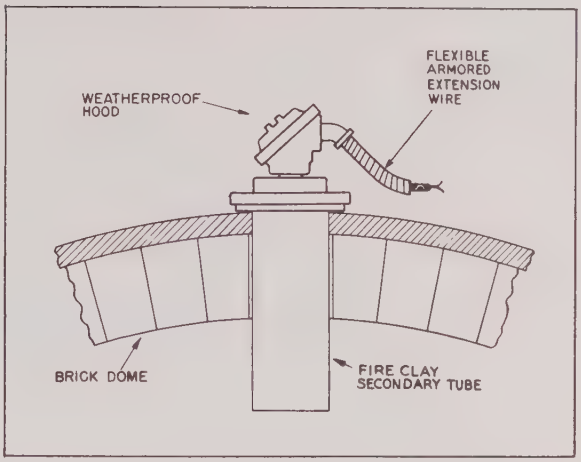

FIG. 14. BRICK, PORCELAIN, TILE, KILN, ETC., ROOF OR DOME WITH PLATINUM COUPLE WITH HEAD SUITABLE FOR OUT DOOR INSTALLATION.

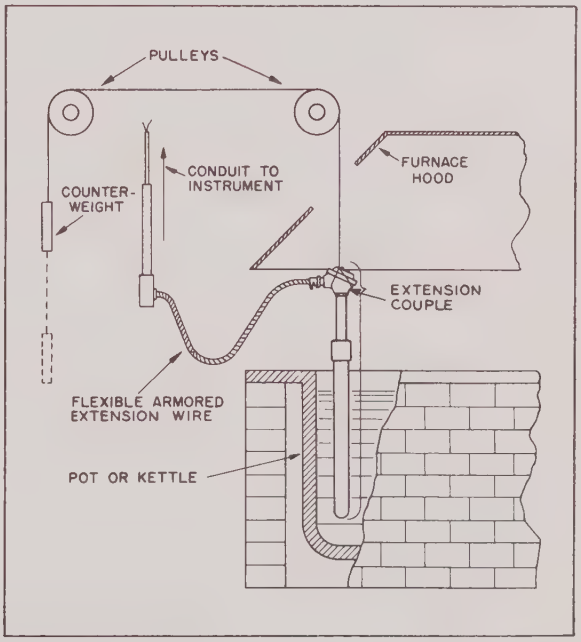

FIG. 15. ALUMINUM, DIECASTING, GALVANIZING, ETC., KETTLE OR POT, WITH HOT & COLD EXTENSION TYPE COUPLE SUSPENDED BY PULLEYS AND COUNTER-WEIGHT, PERMITTING CONVENIENT WITHDRAWAL BETWEEN MELTS, FOR WHITEWASHING, INSPECTION, ETC.

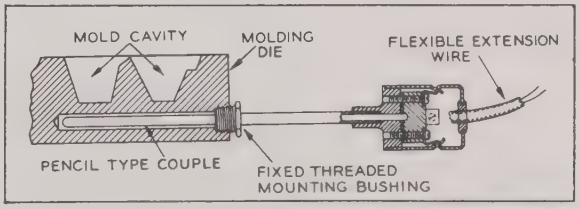

FIG. 17. MOULDING TEMPERATURES OF DIES IN PLATEN PRESS PLASTIC MOULDING TAKEN WITH PENCIL TYPE COUPLE MOUNTED WITH FIXED THREADED BUSHING.

INSTRUCTION NO. P12514

THERMOCOUPLE CALIBRATION DATA

Note: These data are based on the tables of NBS Research Paper 2415 and NBS Circular 508, as adopted by the Scientific Apparatus Makers Association and the Instrument Society of America.

	Page
Iron-Constantan Thermocouples, Type J	2
Copper-Constantan Thermocouples, Type T	3
Chromel-Alumel Thermocouples, Type K (25H)	4, 5
Platinum-Platinum, 10% Rhodium Thermocouples, Type S	6, 7
Platinum-Platinum, 13% Rhodium Thermocouples, Type R	8, 9
Iron-Constantan Thermocouples, Type Y (RP1080)	10

THE BRISTOL COMPANY WATERBURY, CONN. 06720

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°F

IRON-CONSTANTAN THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = −1.22 mv)

EMF IN ABSOLUTE MILLIVOLTS																					
°F.	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50	−55	−60	−65	−70	−75	−80	−85	−90	−95	°F.
−300	−8.74	−8 81	−8.88	−8.95	−9.01																−300
−200	−6.98	−7.08	−7.18	−7.28	−7.38	−7.47	−7.57	−7.66	−7.75	−7.84	−7.93	−8.02	−8.11	−8.19	−8.28	−8.36	−8.44	−8.52	−8.60	−8.67	−200
−100	−4.71	−4.83	−4.95	−5.07	−5.19	−5.31	−5.43	−5.55	−5.66	−5.78	−5.90	−6.01	−6.12	−6.23	−6.34	−6.45	−6.56	−6.66	−6.77	−6.87	−100
0	−2.11	−2.24	−2.38	−2.51	−2.65	−2.78	−2.92	−3.05	−3.18	−3.31	−3.44	−3.57	−3.70	−3.83	−3.96	−4.08	−4.21	−4.34	−4.46	−4.58	0
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	−2.11	−1.97	−1.83	−1.70	−1.56	−1.42	−1.28	−1.14	−1.00	−0.86	−0.72	−0.57	−0.43	−0.29	−0.15	0.00	0.14	0.29	0.43	0.58	0
100	0.72	0.87	1.01	1.16	1.30	1.45	1.60	1.75	1.89	2.04	2.19	2.34	2.49	2.64	2.79	2.94	3.09	3.24	3.39	3.54	100
200	3.69	3.84	3.99	4.14	4.29	4.44	4.59	4.74	4.89	5.05	5.20	5.35	5.50	5.65	5.81	5.96	6.11	6.26	6.42	6.57	200
300	6.72	6.88	7.03	7.18	7.34	7.49	7.65	7.80	7.95	8.11	8.26	8.42	8.57	8.73	8.88	9.03	9.19	9.34	9.50	9.65	300
400	9.81	9.96	10.12	10.27	10.43	10.58	10.74	10.89	11.04	11.20	11.35	11.51	11.66	11.82	11.97	12.12	12.28	12.43	12.59	12.74	400
500	12.90	13.05	13.20	13.36	13.51	13.66	13.82	13.97	14.12	14.28	14.43	14.58	14.74	14.89	15.04	15.20	15.35	15.50	15.66	15.81	500
600	15.96	16.12	16.27	16.42	16.58	16.73	16.89	17.04	17.19	17.35	17.50	17.65	17.81	17.96	18.12	18.27	18.42	18.58	18.73	18.88	600
700	19.04	19.19	19.34	19.50	19.65	19.80	19.96	20.11	20.26	20.42	20.57	20.72	20.88	21.03	21.18	21.33	21.49	21.64	21.79	21.95	700
800	22.10	22.25	22.41	22.56	22.71	22.87	23.02	23.17	23.33	23.48	23.63	23.79	23.94	24.10	24.25	24.40	24.56	24.71	24.87	25.02	800
900	25.18	25.33	25.48	25.64	25.80	25.95	26.11	26.26	26.42	26.58	26.73	26.89	27.04	27.20	27.36	27.52	27.67	27.83	27.99	28.15	900
1000	28.30	28.46	28.62	28.78	28.94	29.10	29.26	29.42	29.58	29.74	29.90	30.06	30.22	30.38	30.54	30.70	30.86	31.02	31.18	31.34	1000
1100	31.50	31.67	31.83	31.99	32.15	32.32	32.48	32.64	32.81	32.97	33.14	33.30	33.46	33.63	33.79	33.96	34.13	34.29	34.46	34.62	1100
1200	34.79	34.96	35.13	35.30	35.47	35.64	35.80	35.98	36.14	36.32	36.49	36.66	36.83	37.00	37.17	37.35	37.52	37.69	37.86	38.04	1200
1300	38.21	38.39	38.56	38.74	38.91	39.09	39.26	39.44	39.61	39.79	39.97	40.14	40.32	40.50	40.68	40.85	41.03	41.21	41.39	41.56	1300
1400	41.74	41.92	42.10	42.28	42.46	42.63	42.81	42.99	43.17	43.35	43.53	43.71	43.88	44.06	44.24	44.42	44.60	44.78	44.96	45.13	1400
1500	45.31	45.49	45.67	45.85	46.02	46.20	46.38	46.56	46.73	46.91	47.09	47.26	47.44	47.61	47.79	47.96	48.14	48.31	48.48	48.66	1500
1600	48.83																				1600

°C

IRON-CONSTANTAN THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = −1.28 mv)

EMF IN ABSOLUTE MILLIVOLTS																					
°C.	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50	−55	−60	−65	−70	−75	−80	−85	−90	−95	°C.
−100	−5.91	−6.11	−6.31	−6.51	−6.70	−6.89	−7.08	−7.26	−7.44	−7.61	−7.78	−7.94	−8.10	−8.25	−8.40	−8.55	−8.68	−8.82	−8.94	−9.06	−100
0	−1.28	−1.53	−1.78	−2.03	−2.28	−2.52	−2.76	−3.00	−3.24	−3.48	−3.71	−3.94	−4.17	−4.40	−4.62	−4 84	−5.06	−5.28	−5.49	−5.70	0
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	−1.28	−1.03	−0.78	−0.52	−0.26	0.00	0.26	0.52	0.78	1.04	1.30	1.57	1.83	2.10	2.37	2.64	2.91	3.18	3.45	3.72	0
100	3.99	4.26	4.53	4.80	5.08	5.35	5.62	5.90	6.17	6.45	6.72	7.00	7.28	7.56	7.83	8.11	8.39	8.67	8.94	9.22	100
200	9.50	9.78	10.06	10.34	10.61	10.89	11.17	11.45	11.73	12.00	12.28	12.56	12.84	13.11	13.39	13.66	13.94	14.22	14.49	14.77	200
300	15.05	15.32	15.60	15.87	16.15	16.43	16.70	16.98	17.26	17.53	17.81	18.09	18.36	18.64	18.92	19.19	19.47	19.74	20.02	20.29	300
400	20.57	20 85	21.12	21.40	21.67	21.95	22.22	22.50	22.78	23.05	23.33	23.60	23.88	24.16	24.44	24.71	24.99	25.27	25.55	25.83	400
500	26.11	26.39	26.67	26.95	27.24	27.52	27.80	28.09	28.37	28.66	28.94	29.23	29.52	29.80	30.09	30.38	30.67	30.96	31.25	31.54	500
600	31.83	32.13	32.42	32.71	33.01	33.30	33.60	33.90	34.20	34.50	34.80	35.10	35.41	35.71	36.02	36.32	36.63	36.94	37.25	37.56	600
700	37.87	38.19	38.50	38.82	39.13	39.45	39.77	40.08	40.40	40.72	41.04	41.36	41.68	42.00	42.32	42.64	42.97	43.29	43.61	43.93	700
800	44.25	44.57	44.90	45.22	45.54	45.86	46.18	46.50	46.81	47.13	47.45	47.76	48.08	48.39	48.70						800

T (24B) °F

COPPER-CONSTANTAN THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = –0.944 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°F.	0	–5	–10	–15	–20	–25	–30	–35	–40	–45	–50	–55	–60	–65	–70	–75	–80	–85	–90	–95	°F.
–300	–6.228	–6.276	–6.323																		–300
–200	–5.055	–5.123	–5.190	–5.256	–5.321	–5.385	–5.448	–5.510	–5.571	–5.632	–5.691	–5.749	–5.807	–5.863	–5.918	–5.973	–6.025	–6.078	–6.129	–6.179	–200
–100	–3.503	–3.589	–3.674	–3.758	–3.841	–3.924	–4.006	–4.087	–4.167	–4.245	–4.324	–4.401	–4.477	–4.553	–4.628	–4.701	–4.773	–4.845	–4.916	–4.986	–100
0	–1.614	–1.715	–1.816	–1.917	–2.016	–2.115	–2.214	–2.311	–2.407	–2.503	–2.598	–2.692	–2.786	–2.878	–2.970	–3.061	–3.151	–3.240	–3.329	–3.416	– 0
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	–1.614	–1.511	–1.407	–1.303	–1.198	–1.093	–0.986	–0.880	–0.773	–0.664	–0.555	–0.445	–0.335	–0.224	–0.112	0.000	0.113	0.227	0.342	0.457	0
100	0.573	0.689	0.807	0.925	1.043	1.163	1.282	1.402	1.523	1.645	1.767	1.891	2.014	2.138	2.263	2.388	2.514	2.640	2.768	2.895	100
200	3.023	3.152	3.281	3.411	3.542	3.673	3.805	3.936	4.070	4.203	4.336	4.471	4.606	4.741	4.877	5.013	5.150	5.288	5.426	5.564	200
300	5.703	5.842	5.982	6.122	6.264	6.405	6.547	6.689	6.832	6.976	7.120	7.263	7.408	7.553	7.698	7.844	7.991	8.138	8.285	8.432	300
400	8.581	8.730	8.879	9.029	9.179	9.329	9.479	9.630	9.782	9.934	10.086	10.239	10.392	10.546	10.699	10.853	11.009	11.164	11.319	11.474	400
500	11.631	11.788	11.944	12.102	12.259	12.418	12.576	12.734	12.894	13.053	13.213	13.373	13.533	13.693	13.855	14.017	14.178	14.340	14.503	14.666	500
600	14.829	14.993	15.157	15.320	15.485	15.649	15.814	15.980	16.145	16.311	16.477	16.644	16.810	16.977	17.145	17.313	17.481	17.649	17.817	17.986	600
700	18.156	18.325	18.495	18.664	18.835	19.005	19.176	19.347	19.519	19.690	19.861										700

T (24B) °C

COPPER-CONSTANTAN THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = –0.990 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°C.	0	–5	–10	–15	–20	–25	–30	–35	–40	–45	–50	–55	–60	–65	–70	–75	–80	–85	–90	–95	°C.
–100	–4.339	–4.478	–4.614	–4.747	–4.877	–5.004	–5.128	–5.249	–5.367	–5.482	–5.593	–5.702	–5.807	–5.909	–6.008	–6.103	–6.195	–6.284	–6.369		–100
0	–0.990	–1.181	–1.370	–1.557	–1.741	–1.923	–2.102	–2.279	–2.453	–2.625	–2.794	–2.961	–3.125	–3.286	–3.445	–3.601	–3.754	–3.904	–4.052	–4.197	0
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	–0.990	–0.797	–0.601	–0.403	–0.203	0.000	0.204	0.411	0.620	0.831	1.045	1.260	1.477	1.697	1.918	2.142	2.367	2.594	2.823	3.054	0
100	3.287	3.522	3.759	3.997	4.237	4.479	4.722	4.967	5.214	5.463	5.713	5.964	6.218	6.472	6.729	6.988	7.246	7.507	7.769	8.033	100
200	8.298	8.565	8.833	9.103	9.373	9.645	9.919	10.193	10.469	10.745	11.025	11.304	11.585	11.867	12.150	12.435	12.720	13.007	13.295	13.583	200
300	13.874	14.165	14.457	14.750	15.045	15.340	15.636	15.934	16.232	16.531	16.831	17.133	17.435	17.737	18.042	18.347	18.652	18.959	19.267	19.575	300
400	19.884																				400

CHROMEL-ALUMEL THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = –0.95 mv)

EMF IN ABSOLUTE MILLIVOLTS

°F.	0	–5	–10	–15	–20	–25	–30	–35	–40	–45	–50	–55	–60	–65	–70	–75	–80	–85	–90	–95	°F.
–300	–6.46	–6.50	–6.55																		–300
–200	–5.24	–5.31	–5.39	–5.46	–5.53	–5.59	–5.66	–5.72	–5.79	–5.85	–5.91	–5.97	–6.03	–6.09	–6.15	–6.20	–6.25	–6.31	–6.36	–6.41	–200
–100	–3.60	–3.69	–3.78	–3.87	–3.96	–4.05	–4.14	–4.22	–4.31	–4.39	–4.47	–4.55	–4.64	–4.71	–4.79	–4.87	–4.95	–5.02	–5.10	–5.17	–100
0	–1.63	–1.74	–1.84	–1.94	–2.05	–2.15	–2.25	–2.35	–2.45	–2.55	–2.65	–2.75	–2.85	–2.94	–3.04	–3.13	–3.23	–3.32	–3.42	–3.51	0
°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	–1.63	–1.53	–1.42	–1.32	–1.21	–1.10	–0.99	–0.88	–0.77	–0.66	–0.55	–0.44	–0.33	–0.22	–0.11	0.00	0.11	0.23	0.34	0.45	0
100	0.57	0.68	0.79	0.91	1.02	1.14	1.25	1.37	1.48	1.60	1.71	1.83	1.94	2.06	2.17	2.29	2.41	2.52	2.64	2.75	100
200	2.87	2.99	3.10	3.22	3.33	3.45	3.56	3.68	3.79	3.91	4.02	4.13	4.25	4.36	4.47	4.58	4.70	4.81	4.92	5.03	200
300	5.14	5.25	5.36	5.47	5.58	5.70	5.81	5.92	6.03	6.14	6.25	6.36	6.47	6.58	6.69	6.80	6.92	7.03	7.14	7.25	300
400	7.36	7.47	7.59	7.70	7.81	7.92	8.03	8.14	8.26	8.37	8.48	8.59	8.71	8.82	8.93	9.05	9.16	9.27	9.39	9.50	400
500	9.62	9.73	9.84	9.96	10.07	10.18	10.30	10.41	10.53	10.64	10.76	10.87	10.99	11.10	11.22	11.33	11.45	11.56	11.68	11.79	500
600	11.91	12.02	12.14	12.25	12.37	12.49	12.60	12.72	12.83	12.95	13.07	13.18	13.30	13.41	13.53	13.65	13.76	13.88	14.00	14.11	600
700	14.23	14.35	14.46	14.58	14.70	14.81	14.93	15.05	15.17	15.28	15.40	15.52	15.64	15.75	15.87	15.99	16.11	16.22	16.34	16.46	700
800	16.58	16.69	16.81	16.93	17.05	17.16	17.28	17.40	17.52	17.63	17.75	17.87	17.99	18.11	18.23	18.34	18.46	18.58	18.70	18.82	800
900	18.94	19.06	19.18	19.29	19.41	19.53	19.65	19.77	19.89	20.00	20.12	20.24	20.36	20.48	20.59	20.71	20.83	20.95	21.07	21.19	900
1000	21.31	21.42	21.54	21.66	21.78	21.90	22.02	22.13	22.25	22.37	22.49	22.61	22.73	22.85	22.96	23.08	23.20	23.32	23.44	23.56	1000
1100	23.68	23.79	23.91	24.03	24.15	24.27	24.39	24.51	24.62	24.74	24.86	24.98	25.10	25.21	25.33	25.45	25.57	25.68	25.80	25.92	1100
1200	26.03	26.15	26.27	26.39	26.50	26.62	26.74	26.85	26.97	27.09	27.20	27.32	27.44	27.55	27.67	27.79	27.91	28.02	28.14	28.26	1200
1300	28.37	28.49	28.61	28.72	28.84	28.96	29.07	29.19	29.30	29.42	29.54	29.65	29.77	29.88	30.00	30.12	30.23	30.35	30.47	30.58	1300
1400	30.70	30.81	30.93	31.04	31.16	31.27	31.39	31.50	31.62	31.73	31.85	31.96	32.07	32.19	32.30	32.42	32.53	32.64	32.76	32.87	1400
1500	32.98	33.10	33.21	33.33	33.44	33.55	33.67	33.78	33.89	34.01	34.12	34.23	34.34	34.46	34.57	34.68	34.80	34.91	35.02	35.13	1500
1600	35.24	35.36	35.47	35.58	35.69	35.81	35.92	36.03	36.14	36.25	36.36	36.48	36.59	36.70	36.81	36.92	37.03	37.14	37.25	37.37	1600
1700	37.48	37.59	37.70	37.81	37.92	38.03	38.14	38.25	38.36	38.47	38.58	38.69	38.80	38.91	39.01	39.12	39.23	39.34	39.45	39.56	1700
1800	39.67	39.78	39.89	40.00	40.10	40.21	40.32	40.43	40.54	40.65	40.75	40.86	40.97	41.08	41.19	41.29	41.40	41.51	41.62	41.72	1800
1900	41.83	41.94	42.04	42.15	42.26	42.36	42.47	42.58	42.68	42.79	42.90	43.00	43.11	43.22	43.32	43.43	43.54	43.64	43.75	43.85	1900
2000	43.96	44.06	44.17	44.27	44.38	44.48	44.59	44.69	44.80	44.90	45.01	45.11	45.22	45.32	45.43	45.53	45.63	45.74	45.84	45.95	2000
2100	46.05	46.15	46.26	46.36	46.46	46.57	46.67	46.77	46.87	46.98	47.08	47.18	47.28	47.39	47.49	47.59	47.69	47.79	47.90	48.00	2100
2200	48.10	48.20	48.30	48.40	48.50	48.60	48.70	48.81	48.91	49.01	49.11	49.21	49.31	49.41	49.51	49.61	49.70	49.80	49.90	50.00	2200
2300	50.10	50.20	50.30	50.40	50.50	50.59	50.69	50.79	50.89	50.99	51.08	51.18	51.28	51.38	51.47	51.57	51.67	51.77	51.86	51.96	2300
2400	52.06	52.15	52.25	52.35	52.44	52 54	52.64	52.73	52.83	52.92	53.02	53.11	53.21	53.30	53.40	53.49	53.59	53.68	53.78	53.87	2400
2500	53.97	54.07	54.16	54.26	54.35	54.45	54.54	54.64	54.73	54.83	54.92	55.02	55.11	55.21	55.30	55.40	55.49	55.59	55.68	55.78	2500
2600	55.87	55.97	56.06	56.16	56.25	56.35	56.44	56.54	56.63	56.73	56.82										2600

CHROMEL-ALUMEL THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0° C = −1.00 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°C.	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50	−55	−60	−65	−70	−75	−80	−85	−90	−95	°C.
−200	−6.75																				−200
−100	−4.49	−4.64	−4.78	−4.92	−5.06	−5.19	−5.32	−5.45	−5.58	−5.70	−5.81	−5.92	−6.03	−6.14	−6.24	−6.34	−6.43	−6.52	−6.60	−6.68	−100
0	−1.00	−1.19	−1.39	−1.58	−1.77	−1.95	−2.14	−2.32	−2.50	−2.68	−2.86	−3.03	−3.20	−3.37	−3.54	−3.71	−3.87	−4.03	−4.19	−4.34	0
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	−1.00	−0.80	−0.60	−0.40	−0.20	0.00	0.20	0.40	0.61	0.81	1.02	1.23	1.43	1.64	1.85	2.05	2.26	2.47	2.68	2.89	0
100	3.10	3.31	3.51	3.72	3.92	4.13	4.33	4.53	4.73	4.93	5.13	5.33	5.53	5.73	5.93	6.13	6.33	6.53	6.73	6.93	100
200	7.13	7.33	7.54	7.74	7.94	8.14	8.34	8.54	8.75	8.95	9.16	9.36	9.57	9.77	9.98	10.18	10.39	10.59	10.80	11.01	200
300	11.21	11.42	11.63	11.83	12.04	12.25	12.46	12.67	12.88	13.09	13.29	13.50	13.71	13.92	14.13	14.34	14.55	14.76	14.98	15.19	300
400	15.40	15.61	15.82	16.03	16.24	16.46	16.67	16.88	17.09	17.30	17.51	17.73	17.94	18.15	18.36	18.58	18.79	19.01	19.22	19.43	400
500	19.65	19.86	20.07	20.28	20.50	20.71	20.92	21.14	21.35	21.56	21.78	21.99	22.20	22.42	22.63	22.84	23.06	23.27	23.49	23.70	500
600	23.91	24.12	24.34	24.55	24.76	24.98	25.19	25.40	25.61	25.82	26.03	26.24	26.45	26.66	26.87	27.08	27.29	27.50	27.72	27.93	600
700	28.14	28.35	28.56	28.77	28.97	29.18	29.39	29.60	29.81	30.02	30.23	30.44	30.65	30.85	31.06	31.27	31.48	31.68	31.89	32.09	700
800	32.30	32.50	32.71	32.91	33.12	33.32	33.53	33.73	33.93	34.14	34.34	34.54	34.75	34.95	35.15	35.35	35.55	35.76	35.96	36.16	800
900	36.36	36.56	36.76	36.96	37.16	37.36	37.56	37.76	37.95	38.15	38.35	38.55	38.75	38.94	39.14	39.34	39.53	39.73	39.92	40.12	900
1000	40.31	40.51	40.70	40.90	41.09	41.29	41.48	41.67	41.87	42.06	42.25	42.44	42.63	42.83	43.02	43.21	43.40	43.59	43.78	43.97	1000
1100	44.16	44.35	44.54	44.73	44.92	45.11	45.29	45.48	45.67	45.85	46.04	46.23	46.41	46.60	46.78	46.97	47.15	47.34	47.52	47.70	1100
1200	47.89	48.07	48.25	48.43	48.62	48.80	48.98	49.16	49.34	49.52	49.69	49.87	50.05	50.23	50.41	50.58	50.76	50.94	51.11	51.29	1200
1300	51.46	51.64	51.81	51.99	52.16	52.34	52.51	52.68	52.85	53.03	53.20	53.37	53.54	53.71	53.88						1300

S °F

PLATINUM-PLATINUM, 10% RHODIUM THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = −0.136 mv)

EMF IN ABSOLUTE MILLIVOLTS

°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	−0.236	−0.220	−0.205	−0.189	−0.173	−0.158	−0.142	−0.127	−0.112	−0.096	−0.080	−0.065	−0.049	−0.032	−0.016	0.000	0.017	0.034	0.051	0.068	0
100	0.085	0.102	0.120	0.138	0.155	0.173	0.191	0.210	0.228	0.247	0.265	0.284	0.303	0.322	0.341	0.360	0.380	0.399	0.419	0.439	100
200	0.459	0.479	0.499	0.519	0.540	0.560	0.581	0.602	0.622	0.643	0.664	0.686	0.707	0.728	0.750	0.771	0.793	0.815	0.837	0.858	200
300	0.881	0.903	0.925	0.947	0.970	0.992	1.015	1.037	1.060	1.083	1.106	1.128	1.151	1.175	1.198	1.221	1.244	1.268	1.291	1.314	300
400	1.338	1.362	1.385	1.409	1.433	1.457	1.480	1.504	1.528	1.552	1.576	1.600	1.625	1.649	1.673	1.697	1.722	1.746	1.771	1.795	400
500	1.820	1.845	1.869	1.894	1.919	1.944	1.969	1.994	2.019	2.044	2.069	2.094	2.119	2.145	2.170	2.195	2.221	2.246	2.271	2.297	500
600	2.322	2.348	2.374	2.399	2.425	2.451	2.477	2.502	2.528	2.554	2.580	2.606	2.632	2.658	2.684	2.710	2.736	2.762	2.788	2.815	600
700	2.841	2.867	2.893	2.920	2.946	2.972	2.999	3.025	3.052	3.078	3.104	3.131	3.157	3.184	3.211	3.237	3.264	3.290	3.317	3.344	700
800	3.370	3.397	3.424	3.451	3.478	3.504	3.531	3.558	3.585	3.612	3.639	3.666	3.693	3.720	3.747	3.774	3.801	3.828	3.855	3.883	800
900	3.910	3.937	3.964	3.992	4.019	4.046	4.074	4.101	4.128	4.156	4.183	4.211	4.238	4.266	4.294	4.321	4.349	4.376	4.404	4.432	900
1000	4.460	4.487	4.515	4.543	4.571	4.599	4.627	4.654	4.682	4.710	4.738	4.766	4.794	4.823	4.851	4.879	4.907	4.935	4.963	4.992	1000
1100	5.020	5.048	5.076	5.105	5.133	5.162	5.190	5.218	5.247	5.275	5.304	5.333	5.361	5.390	5.419	5.447	5.476	5.504	5.533	5.562	1100
1200	5.590	5.619	5.648	5.677	5.706	5.735	5.763	5.792	5.821	5.850	5.879	5.908	5.937	5.966	5.995	6.025	6.054	6.083	6.112	6.141	1200
1300	6.171	6.200	6.229	6.258	6.288	6.317	6.347	6.376	6.406	6.435	6.465	6.494	6.524	6.553	6.583	6.613	6.642	6.672	6.702	6.731	1300
1400	6.761	6.791	6.821	6.851	6.881	6.910	6.940	6.970	7.000	7.030	7.060	7.090	7.121	7.151	7.181	7.211	7.241	7.271	7.302	7.332	1400
1500	7.362	7.393	7.423	7.453	7.484	7.514	7.545	7.575	7.606	7.636	7.667	7.698	7.728	7.759	7.789	7.820	7.851	7.882	7.912	7.943	1500
1600	7.974	8.005	8.036	8.067	8.098	8.129	8.160	8.191	8.222	8.253	8.284	8.315	8.346	8.377	8.409	8.440	8.471	8.502	8.534	8.565	1600
1700	8.596	8.628	8.659	8.691	8.722	8.754	8.785	8.817	8.848	8.880	8.912	8.943	8.975	9.007	9.038	9.070	9.102	9.134	9.166	9.197	1700
1800	9.229	9.261	9.293	9.325	9.357	9.389	9.421	9.453	9.485	9.518	9.550	9.582	9.614	9.646	9.679	9.711	9.743	9.776	9.808	9.840	1800
1900	9.873	9.905	9.938	9.970	10.003	10.035	10.068	10.101	10.133	10.166	10.198	10.231	10.264	10.297	10.329	10.362	10.395	10.428	10.461	10.493	1900
2000	10.526	10.559	10.592	10.625	10.658	10.691	10.724	10.757	10.790	10.823	10.856	10.889	10.922	10.955	10.988	11.021	11.054	11.088	11.121	11.154	2000
2100	11.187	11.220	11.253	11.287	11.320	11.353	11.386	11.420	11.453	11.486	11.519	11.553	11.586	11.619	11.653	11.686	11.719	11.752	11.786	11.819	2100
2200	11.853	11.886	11.919	11.953	11.986	12.019	12.053	12.086	12.120	12.153	12.186	12.220	12.253	12.287	12.320	12.354	12.387	12.420	12.454	12.487	2200
2300	12.521	12.554	12.588	12.621	12.654	12.688	12.721	12.755	12.788	12.821	12.855	12.888	12.922	12.955	12.988	13.022	13.055	13.088	13.122	13.155	2300
2400	13.189	13.222	13.255	13.289	13.322	13.355	13.389	13.422	13.455	13.489	13.522	13.555	13.589	13.622	13.655	13.689	13.722	13.755	13.788	13.822	2400
2500	13.855	13.888	13.922	13.955	13.988	14.021	14.055	14.088	14.121	14.154	14.188	14.221	14.254	14.287	14.321	14.354	14.387	14.420	14.453	14.487	2500
2600	14.520	14.553	14.586	14.619	14.653	14.686	14.719	14.752	14.785	14.818	14.852	14.885	14.918	14.951	14.984	15.017	15.050	15.083	15.117	15.150	2600
2700	15.183	15.216	15.249	15.282	15.315	15.348	15.381	15.414	15.447	15.480	15.513	15.546	15.579	15.612	15.645	15.678	15.711	15.744	15.777	15.810	2700
2800	15.843	15.876	15.909	15.942	15.975	16.008	16.041	16.074	16.107	16.139	16.172	16.205	16.238	16.271	16.304	16.337	16.370	16.402	16.435	16.468	2800
2900	16.501	16.534	16.566	16.599	16.632	16.665	16.698	16.730	16.763	16.796	16.829	16.861	16.894	16.927	16.959	16.992	17.025	17.058	17.090	17.123	2900
3000	17.156	17.188	17.221	17.253	17.286	17.319	17.351	17.384	17.416	17.449	17.482	17.514	17.547	17.579	17.612	17.644	17.677	17.709	17.742	17.774	3000
3100	17.807	17.839	17.872	17.904	17.937	17.969	18.001	18.034	18.066	18.099	18.131	18.163	18.196	18.228	18.260	18.293	18.325	18.357	18.390	18.422	3100
3200	18.454	18.486	18.519	18.551																	3200

PLATINUM-PLATINUM, 10% RHODIUM THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0°C = –0.143 mv)

EMF IN ABSOLUTE MILLIVOLTS																				
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	–0.143	–0.115	–0.087	–0.059	–0.030	0.000	0.030	0.061	0.092	0.123	0.156	0.188	0.221	0.254	0.288	0.323	0.357	0.392	0.428	0.464	0
100	0.500	0.537	0.574	0.611	0.649	0.687	0.726	0.764	0.803	0.843	0.882	0.922	0.963	1.003	1.044	1.085	1.126	1.168	1.209	1.251	100
200	1.293	1.336	1.378	1.421	1.464	1.507	1.550	1.593	1.637	1.681	1.725	1.769	1.813	1.857	1.902	1.947	1.992	2.037	2.082	2.127	200
300	2.173	2.219	2.264	2.310	2.356	2.403	2.449	2.495	2.542	2.588	2.635	2.682	2.729	2.776	2.823	2.871	2.918	2.965	3.013	3.060	300
400	3.108	3.156	3.204	3.251	3.299	3.347	3.396	3.444	3.492	3.540	3.589	3.637	3.686	3.735	3.783	3.832	3.881	3.930	3.979	4.028	400
500	4.078	4.127	4.176	4.226	4.276	4.325	4.375	4.425	4.475	4.525	4.575	4.625	4.675	4.726	4.776	4.827	4.877	4.928	4.979	5.030	500
600	5.081	5.132	5.183	5.234	5.286	5.337	5.389	5.440	5.492	5.543	5.595	5.647	5.699	5.751	5.803	5.855	5.907	5.959	6.012	6.064	600
700	6.117	6.169	6.222	6.275	6.328	6.381	6.434	6.487	6.540	6.594	6.647	6.701	6.754	6.808	6.862	6.915	6.969	7.023	7.077	7.132	700
800	7.186	7.240	7.295	7.349	7.404	7.459	7.513	7.568	7.623	7.678	7.733	7.789	7.844	7.899	7.955	8.010	8.066	8.122	8.177	8.233	800
900	8.289	8.345	8.402	8.458	8.514	8.571	8.627	8.684	8.740	8.797	8.854	8.911	8.968	9.025	9.082	9.139	9.197	9.254	9.312	9.369	900
1000	9.427	9.485	9.543	9.601	9.659	9.717	9.775	9.833	9.892	9.950	10.009	10.067	10.126	10.185	10.244	10.303	10.362	10.421	10.480	10.539	1000
1100	10.598	10.658	10.717	10.776	10.836	10.895	10.955	11.014	11.074	11.134	11.193	11.253	11.313	11.373	11.432	11.492	11.552	11.612	11.672	11.732	1100
1200	11.792	11.852	11.912	11.972	12.032	12.093	12.153	12.213	12.273	12.333	12.393	12.454	12.514	12.574	12.634	12.694	12.754	12.814	12.875	12.935	1200
1300	12.995	13.055	13.115	13.175	13.235	13.295	13.355	13.415	13.475	13.535	13.595	13.655	13.715	13.775	13.835	13.895	13.955	14.014	14.074	14.134	1300
1400	14.194	14.254	14.314	14.373	14.433	14.493	14.553	14.612	14.672	14.732	14.792	14.851	14.911	14.970	15.030	15.090	15.149	15.209	15.268	15.328	1400
1500	15.387	15.447	15.506	15.566	15.625	15.684	15.744	15.803	15.863	15.922	15.981	16.040	16.100	16.159	16.218	16.277	16.336	16.395	16.454	16.514	1500
1600	16.573	16.632	16.691	16.750	16.809	16.867	16.926	16.985	17.044	17.103	17.162	17.220	17.279	17.338	17.396	17.455	17.514	17.572	17.631	17.689	1600
1700	17.748	17.806	17.865	17.923	17.981	18.040	18.098	18.156	18.215	18.273	18.331	18.389	18.447	18.505							1700

R °F

PLATINUM-PLATINUM, 13% RHODIUM THERMOCOUPLES

Degrees Fahrenheit (Int. 1948) Cold End at 75° F (EMF at 32° F = −0.135 mv)

EMF IN ABSOLUTE MILLIVOLTS

°F.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°F.
0	−0.235	−0.220	−0.204	−0.188	−0.173	−0.157	−0.141	−0.126	−0.111	−0.096	−0.080	−0.064	−0.049	−0.032	−0.016	0.000	0.017	0.034	0.051	0.068	0
100	0.085	0.102	0.120	0.137	0.156	0.173	0.192	0.210	0.228	0.246	0.265	0.284	0.303	0.322	0.341	0.361	0.381	0.401	0.421	0.441	100
200	0.461	0.481	0.502	0.522	0.543	0.565	0.586	0.607	0.628	0.650	0.672	0.693	0.715	0.737	0.759	0.782	0.804	0.827	0.849	0.872	200
300	0.895	0.917	0.940	0.963	0.986	1.009	1.032	1.056	1.079	1.103	1.126	1.150	1.174	1.198	1.222	1.246	1.271	1.295	1.320	1.345	300
400	1.369	1.394	1.418	1.443	1.468	1.493	1.518	1.543	1.568	1.594	1.619	1.644	1.670	1.696	1.721	1.747	1.773	1.799	1.825	1.851	400
500	1.877	1.903	1.930	1.956	1.982	2.009	2.035	2.062	2.088	2.115	2.142	2.168	2.195	2.222	2.249	2.277	2.303	2.331	2.358	2.385	500
600	2.412	2.440	2.467	2.495	2.522	2.550	2.577	2.605	2.633	2.661	2.688	2.716	2.744	2.772	2.800	2.828	2.856	2.884	2.912	2.940	600
700	2.968	2.997	3.025	3.053	3.082	3.110	3.138	3.167	3.195	3.224	3.252	3.281	3.310	3.338	3.367	3.396	3.425	3.454	3.483	3.512	700
800	3.542	3.571	3.600	3.629	3.659	3.688	3.717	3.747	3.776	3.806	3.835	3.864	3.894	3.923	3.952	3.981	4.011	4.040	4.070	4.100	800
900	4.129	4.159	4.189	4.219	4.249	4.278	4.308	4.338	4.368	4.398	4.428	4.458	4.489	4.519	4.550	4.580	4.611	4.641	4.672	4.702	900
1000	4.733	4.764	4.795	4.825	4.856	4.887	4.918	4.949	4.980	5.011	5.041	5.073	5.103	5.135	5.166	5.197	5.228	5.259	5.291	5.322	1000
1100	5.353	5.384	5.416	5.447	5.479	5.510	5.542	5.574	5.606	5.638	5.670	5.702	5.734	5.766	5.798	5.829	5.861	5.893	5.925	5.957	1100
1200	5.990	6.021	6.053	6.085	6.117	6.150	6.182	6.214	6.246	6.279	6.311	6.344	6.376	6.409	6.442	6.474	6.507	6.539	6.572	6.605	1200
1300	6.638	6.670	6.703	6.736	6.769	6.802	6.835	6.868	6.902	6.934	6.968	7.001	7.034	7.067	7.100	7.134	7.167	7.201	7.234	7.268	1300
1400	7.301	7.335	7.368	7.402	7.436	7.470	7.504	7.537	7.571	7.605	7.639	7.673	7.707	7.742	7.776	7.810	7.844	7.878	7.912	7.946	1400
1500	7.981	8.015	8.049	8.083	8.118	8.152	8.187	8.221	8.256	8.291	8.325	8.360	8.395	8.430	8.464	8.499	8.534	8.569	8.604	8.639	1500
1600	8.674	8.709	8.744	8.779	8.814	8.849	8.884	8.919	8.955	8.990	9.026	9.061	9.097	9.132	9.168	9.203	9.239	9.274	9.310	9.346	1600
1700	9.381	9.417	9.452	9.488	9.524	9.559	9.595	9.631	9.667	9.703	9.739	9.775	9.811	9.847	9.884	9.921	9.957	9.994	10.029	10.066	1700
1800	10.102	10.139	10.175	10.212	10.248	10.285	10.321	10.358	10.394	10.431	10.468	10.504	10.541	10.577	10.614	10.651	10.688	10.726	10.763	10.801	1800
1900	10.838	10.876	10.913	10.950	10.987	11.025	11.062	11.100	11.138	11.175	11.213	11.250	11.289	11.326	11.364	11.402	11.440	11.478	11.516	11.554	1900
2000	11.591	11.630	11.667	11.705	11.743	11.781	11.819	11.857	11.894	11.933	11.970	12.009	12.047	12.085	12.123	12.161	12.200	12.238	12.276	12.315	2000
2100	12.353	12.391	12.429	12.467	12.506	12.544	12.583	12.621	12.660	12.698	12.736	12.774	12.813	12.851	12,890	12.928	12.967	13.005	13.043	13.081	2100
2200	13.120	13.158	13.197	13.236	13.274	13.313	13.351	13.390	13.429	13.467	13.506	13.544	13.583	13.621	13.660	13.698	13.737	13.776	13.814	13.853	2200
2300	13.892	13.930	13.969	14.007	14.046	14.084	14.123	14.161	14.200	14.239	14.277	14.316	14.355	14.393	14.432	14.471	14.509	14.548	14.586	14.625	2300
2400	14.663	14.702	14.740	14.779	14.817	14.856	14.894	14.933	14.972	15.010	15.049	15.087	15.126	15.164	15.203	15.242	15.280	15.319	15.357	15.396	2400
2500	15.433	15.472	15.510	15.549	15.587	15.626	15.665	15.703	15.742	15.780	15.819	15.857	15.896	15.935	15.973	16.012	16.050	16.089	16.128	16.166	2500
2600	16.205	16.243	16.282	16.320	16.359	16.397	16.436	16.475	16.513	16.552	16.590	16.629	16.667	16.707	16.745	16.783	16.822	16.860	16.898	16.937	2600
2700	16.975	17.013	17.051	17.090	17.128	17.166	17.205	17.243	17.281	17.320	17.358	17.397	17.434	17.473	17.511	17.550	17.588	17.626	17.664	17.702	2700
2800	17.740	17.778	17.816	17.854	17.892	17.930	17.968	18 006	18.044	18.083	18.120	18.159	18.197	18.235	18.273	18.311	18.349	18.387	18.425	18.463	2800
2900	18.501	18.539	18.577	18.615	18.653	18.691	18.729	18.767	18.805	18.843	18.881	18.919	18.957	18.994	19.033	19.070	19.108	19.146	19.183	19.221	2900
3000	19.259	19.297	19.335	19.373	19.410	19.448	19.486	19.524	19.562	19.600	19.638	19.676	19.713	19.751	19.789	19.827	19.864	19.902	19.940	19.977	3000
3100	20.015																				3100

PLATINUM-PLATINUM, 13% RHODIUM THERMOCOUPLES

Degrees Celsius (Centigrade, Int. 1948) Cold End at 25° C (EMF at 0°C = −0.142 mv)

EMF IN ABSOLUTE MILLIVOLTS																					
°C.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	°C.
0	−0.142	−0.115	−0.087	−0.059	−0.030	0.000	0.030	0.061	0.092	0.123	0.156	0.188	0.221	0.255	0.289	0.323	0.358	0.394	0.430	0.467	0
100	0.503	0.541	0.579	0.617	0.656	0.695	0.735	0.775	0.815	0.856	0.897	0.938	0.979	1.021	1.063	1.105	1.148	1.191	1.235	1.278	100
200	1.323	1.367	1.411	1.456	1.501	1.546	1.592	1.637	1.684	1.730	1.776	1.823	1.870	1.917	1.965	2.012	2.060	2.108	2.156	2.204	200
300	2.253	2.302	2.351	2.400	2.449	2.499	2.548	2.598	2.648	2.698	2.748	2.798	2.849	2.899	2.950	3.001	3.052	3.103	3.154	3.205	300
400	3.257	3.309	3.360	3.412	3.465	3.517	3.570	3.622	3.675	3.728	3.781	3.834	3.887	3.939	3.992	4.045	4.099	4.152	4.206	4.259	400
500	4.313	4.367	4.421	4.476	4.530	4.585	4.640	4.695	4.751	4.806	4.862	4.917	4.973	5.028	5.084	5.140	5.196	5.252	5.308	5.365	500
600	5.421	5.478	5.535	5.592	5.650	5.707	5.765	5.822	5.880	5.937	5.995	6.052	6.110	6.168	6.226	6.285	6.343	6.402	6.460	6.519	600
700	6.578	6.637	6.696	6.756	6.815	6.875	6.934	6.994	7.053	7.113	7.173	7.234	7.294	7.355	7.415	7.476	7.537	7.598	7.659	7.721	700
800	7.782	7.844	7.905	7.967	8.028	8.090	8.152	8.214	8.277	8.339	8.402	8.464	8.527	8.590	8.653	8.716	8.779	8.842	8.905	8.969	800
900	9.033	9.097	9.161	9.225	9.289	9.353	9.417	9.481	9.545	9.610	9.674	9.739	9.804	9.870	9.935	10.001	10.066	10.132	10.197	10.263	900
1000	10.329	10.395	10.461	10.527	10.593	10.659	10.727	10.794	10.861	10.928	10.996	11.063	11.131	11.198	11.266	11.334	11.402	11.471	11.539	11.607	1000
1100	11.675	11.743	11.812	11.880	11.948	12.017	12.085	12.154	12.223	12.292	12.361	12.430	12.499	12.568	12.637	12.706	12.775	12.844	12.913	12.983	1100
1200	13.051	13.121	13.190	13.260	13.329	13.398	13.468	13.537	13.607	13.676	13.746	13.815	13.885	13.954	14.023	14.093	14.162	14.232	14.301	14.371	1200
1300	14.440	14.510	14.579	14.649	14.718	14.787	14.857	14.926	14.996	15.065	15.134	15.203	15.273	15.342	15.411	15.481	15.550	15.619	15.689	15.758	1300
1400	15.827	15.897	15.966	16.036	16.105	16.175	16.244	16.313	16.382	16.452	16.521	16.591	16.660	16.730	16.798	16.868	16.937	17.006	17.075	17.144	1400
1500	17.213	17.282	17.351	17.419	17.489	17.557	17.626	17.695	17.764	17.832	17.901	17.969	18.037	18.106	18.174	18.243	18.311	18.380	18.448	18.517	1500
1600	18.585	18.654	18.722	18.790	18.859	18.927	18.995	19.063	19.131	19.199	19.267	19.335	19.403	19.472	19.540	19.608	19.676	19.744	19.812	19.880	1600
1700	19.948																				1700

PARTS LIST P12055-A

MODEL 560 AND 570

WIDE STRIP DYNAMASTER ® RECORDER

CONTENTS

	Page
Door Assembly	2-3
Case and Case Interior	2-3
Interior of 0.4 Second Instrument	4
Front of Hinged Panel	5
Rear of Hinged Panel	6-7
Chart-Drive Mechanism	8-9
Chart-Drive Motors	10-11
Pen Assembly for Single-Pen Recorder	12-13
Pen Assembly Support for Single-Pen Recorder	12-13
Pen Assembly for Two-Pen Recorder	14-15
Pen Assembly Support for Two-Pen Recorder	14-15
Multiple-Printing Mechanism	16-17
Multiple-Printing Mechanism Support	16-17
Balancing Mechanism for No. 2 Pen of 2-Pen Recorder	18-19
Multiple-Switching Mechanism	20-21-22
Table of Motors and Change Gears for Multiple-Switching Mechanism	22
Table of Motors and Change Gears for Chart Drive	23
Table of Motors and Change Gears for 2-Speed Chart Drive	24
Power Pack (for d-c Resistance Recorder)	24
Automatic Pen Lifter	24
Pen Accessories	24

THE BRISTOL COMPANY WATERBURY, CONN. 06720

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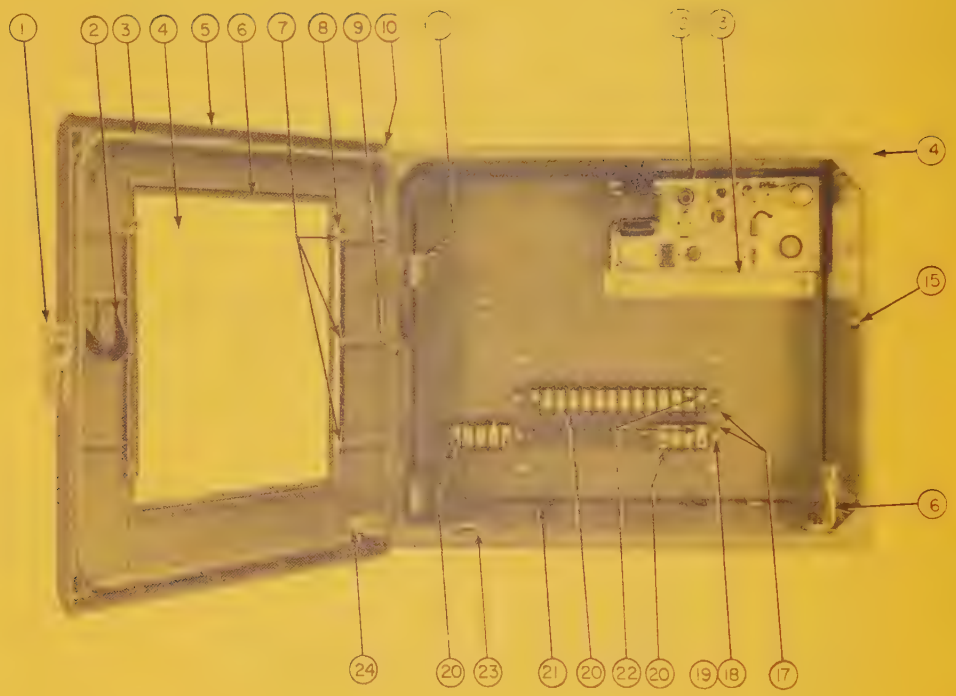


FIGURE 1. DOOR AND CASE INTERIOR

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
1	282615-00-8	Handle complete with lock
	282616-00-4	Handle without lock
	*287239-00-4	Stop pin
	*294738-00-2	Latch plate
2	288751-00-4	Hook complete
	282415-00-9	10-32 x 1/4" Bristo cup-point setscrew
	*282630-00-7	Flat spring
3	282608-00-1	Rubber gasket (62" long)
4	283644-00-1	Glass
5		Door complete (Specify model & serial number of instrument)
6	284725-00-5	Gasket (47" long)
7	282656-00-6	6 x 3/16" Fillister-head screw
8	285232-00-2	Glass clip
9	285236-00-8	Hinge bracket
	*266539-00-9	10-32 x 3/8" Fillister-head screw
	*266541-00-3	10-32 x 1/2" Fillister-head screw
	*282413-00-6	10-32 x 3/16" Bristo flat-point setscrew
10	282654-00-3	Door hinge
	*292693-00-1	10-32 x 7/16" Flat-head screw
11	283996-00-5	Hinge for hinged panel on 1-pen and multiple-point instruments
	341078-00-0	Hinge for hinged panel on 2-pen instruments
	*285208-00-4	Hinge pin
	212721-00-3	Washer
12		Series D amplifiers (see parts list P12077)
		Series "L10" amplifiers (see parts list P12609)
		Series "N" amplifiers (100K) Solid State (see parts list P12553)
	334114-00-4	Filter (100K)
	334651-00-1	Filter (1K)
13	313139-00-8	Amplifier mounting strap
	266537-00-6	#10-32 x 1/4" Fillister-head screw
14		Case body complete (Specify model & serial number of instrument)
15	292126-00-0	Roller
	*296127-00-0	Roller stud
16	285220-00-4	Latch complete for hinged panel
	289659-00-0	1/4" - 20 x 3/8" Hexagon socket-head cap screw

* Not shown

KEY TO FIGURE 1. CONTINUED

17	286092-00-0	Terminal mounting strap (11 7/8" long)
	286093-00-6	Terminal mounting strap (8 13/16" long)
18		Terminal strap mounting post
	234954-00-0	1/2" long
	288102-00-2	1 1/4" long
	288106-00-8	2" long
	289869-00-5	2 3/4" long
19		Terminal strap mounting screw
	266568-00-9	10-32 x 3/4" Flat-head screw
	266545-00-9	10-32 x 3/4" Fillister-head screw
	266572-00-6	10-32 x 1 1/2" Flat-head screw
	265984-00-9	10-32 x 1 1/2" Fillister-head screw
	266575-00-5	10-32 x 2 1/4" Flat-head screw
	288107-00-4	10-32 x 2 1/4" Fillister-head screw
	289870-00-3	10-32 x 3" Round-head screw
20		Terminal blocks
	274804-00-0	2 terminals
	287235-00-9	3 terminals
	287236-00-5	4 terminals
	293670-00-5	5 terminals
	287238-00-8	6 terminals
	276643-00-3	8 terminals
	285288-00-8	9 terminals
	288098-00-5	12 terminals
		Terminal marking strip (give marking and number of terminals)
21	286026-00-7	Rubber grommet (for 1 11/16" conduit hole)
	272691-00-3	Rubber grommet (for 1 1/16" conduit hole)
22	287936-00-7	#10 x 1" Self-tapping screw
	*272166-00-6	Spacer
	*210075-00-7	Washer
23	287392-00-7	Door-stop screw
	244739-00-5	Collar
	286027-00-3	Door stop
24	240066-00-6	8/32 x 1/4" Fillister-head screw
		Case Mounting Brackets
	*292030-01-0	Bracket
	*232193-00-2	1/4" - 20 x 1/2" Hex-head screw for mounting bracket to case
	*283848-00-6	5/16" - 24 x 2 1/2 Headless screw for flush-mounted case
	*250706-00-8	5/16" - 24 Hex nut for screw 283848-00-6
	*292031-00-9	Cup washer for screw 283848-00-6

*Not shown

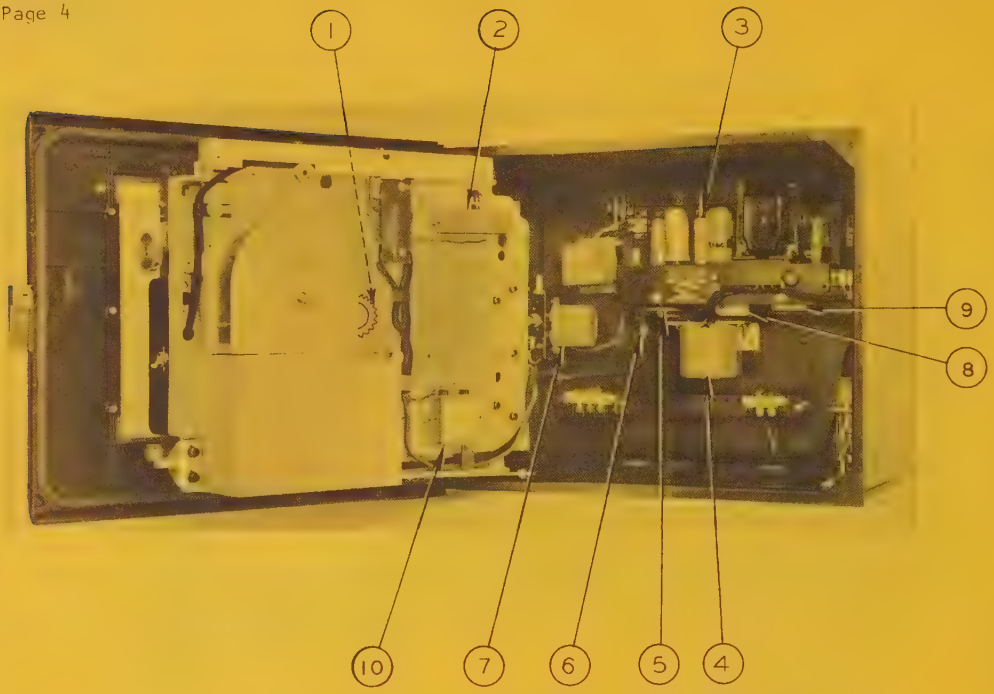


FIGURE 2. PHOTO OF HIGH-SPEED (0.4 SEC.) DYNAMASTER

ITEM	PART NO.	DESCRIPTION
1	308351-00-2	Motor-generator assembly complete
	235639-00-5	#8 Shakeproof washer
	294855-00-9	#8-32 Nut
	310593-00-0	#8-32 x 5/16" Flat-head screw
	308349-00-8	Mounting plate complete
	332446-00-0	Motor-generator
	304989-00-2	Pinion complete (on motor-generator shaft)
	282403-00-0	#6-40 x 1/8" Flat-point setscrew
	304996-00-9	Spring
	304993-00-0	Gear hub collar
	304992-00-3	Rear gear assembly
	304990-00-0	Front gear assembly
2	334806-00-3	Rectifier for pen-lifter relay
	*218339-00-3	6-40 x 3/16" Fillister-head screw for mounting rectifier
3	341096-00-8	Series "D" amplifier (see parts list P12077 for breakdown)
	302229-00-0	Amplifier shelf
4	292736-00-2	Output transformer
	*266537-00-6	10-32 x 1/4" Fillister-head screw for mounting transformer
	*235638-00-5	#10 Lockwasher
5	303820-00-4	Thyrite disk complete (used with 332162-00-1 only)
	*262290-00-6	6-40 x 1 1/16" Fillister-head screw for mounting Thyrite disk
	*243040-00-8	Washer
	*302241-00-0	Spacer
	*220903-00-0	6-40 Hexagon nut
6	302517-00-6	Stick resistor (used with 332162-00-1 only)
	*292315-00-7	6-40 x 2" Fillister-head screw for mounting stick resistor
	*243040-00-8	Washer
	*200256-00-9	Retaining washer
7	331216-00-0	Feed-back unit complete (used with 332162-00-1 only)
	370455-01-0	Transformer
	291050-00-0	Rheostat (60 ohm)
	302242-00-7	Rheostat (2 meg.)
	283979-00-3	Resistor (470K, 1/2 watt)
	290575-00-1	Resistor (10K, 1 watt)
	284549-00-2	Potentiometer cap
	332702-00-6	Feedback unit complete (used with 308351-00-02 only)
8	293740-00-3	Capacitor (1.25 mfd. 600 V.)
	*266537-00-6	10-32 x 1/4" Fillister-head screw for mounting capacitor
	*235638-00-5	#10 Lockwasher
9	274480-00-0	Capacitor (.5 mfd. 600 V.)
10	290059-00-3	Capacitor (1.00 mfd. 600 V.)

*Not Shown

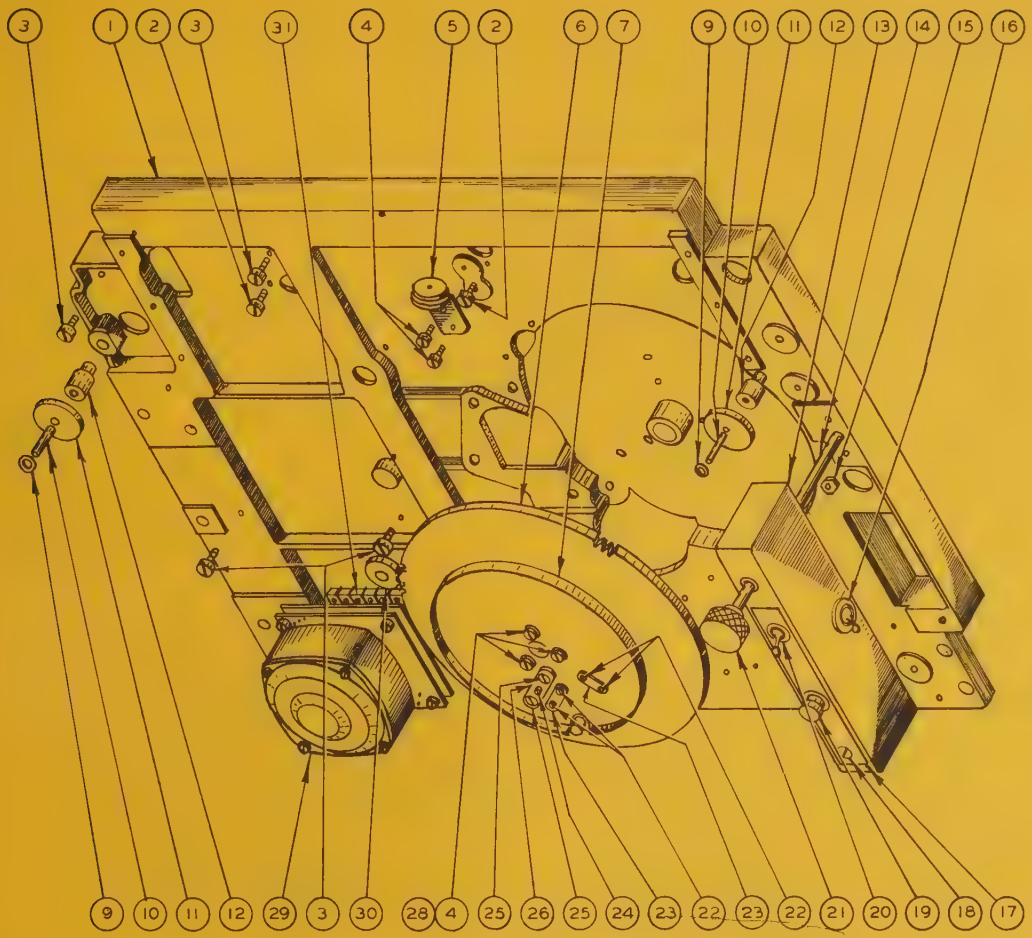


FIGURE 3. FRONT OF HINGED PANEL

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
1	298350-00-9	Mounting frame for 1-pen and multiple point instruments
	331151-00-6	Mounting frame for 2-pen instruments
2	266539-00-9	10-32 x 3/8" Fillister-head screw
3	266539-00-9	10-32 x 3/8" Fillister-head screw for 2-pen instruments
	242098-00-2	10-32 x 7/16" Fillister-head screw for multiple-point instruments
4	231427-00-0	6-40 x 5/16" Fillister-head screw
5	288183-00-2	Pulley and bracket complete
	276283-00-7	Pulley
	279854-00-5	Retaining ring
6	292578-00-8	Bull gear complete for 3, 4.5, 7 & 24 second pen travel, includes setscrew and items 4, 7, 22 thru 26 and 28
	286052-00-8	Bull gear & hub only for 3, 4.5, 7 & 24 second pen travel
	293929-00-9	Bull gear complete for 1 & 0.4 second pen travel, includes set-screw & items 4, 7, 22 thru 26 & 28
	293360-00-6	Bull gear & hub only for 1 and 0.4 second pen travel
	289049-00-8	5/16- 18 Flat-point setscrew
	332445-00-3	Bull gear for new style 0.4 second

KEY TO FIGURE 3. CONTINUED

ITEM	PART NO.	DESCRIPTION
7	285255-00-2	Sheave
	289030-00-5	Drive cord
9	280607-00-8	Retaining ring (1/8" shaft) (see item 11)
10	285291-00-9	Pulley shaft (see item 11)
11	292579-00-4	Cord-pulley assembly complete including setscrew and items 9, 10 & 12 for 3, 4.5, 7 and 24 sec. pen travel
	302205-00-4	Cord-pulley assembly complete including setscrew and item 12 for 1 and 0.4 second pen travel
	282403-00-0	Setscrew for item 11
12	285292-00-5	Mounting stud for 3, 4.5, 7 and 24 second pen travel (see item 11)
	302210-00-8	Mounting stud for 1 and 0.4 second pen travel (see item 11)
13	286025-00-0	Switch housing for 1-pen and multiple-point instrument
	292934-00-9	Switch housing same as above, but drilled for 2-speed chart-drive switch
	331557-00-2	Switch housing for 2-pen instrument
14	288157-00-1	Control-knob shaft
15	272055-00-0	10-32 Hexagon nut
16	262827-00-0	2-speed chart-drive switch
17	286098-00-8	Switch plate for d-c potentiometer type instrument (2 switches)
	286099-00-4	Switch plate for a-c bridge type instrument (1 switch)
18	291089-00-3	6-40 x 1/4" Fillister-head screw
19	254261-00-0	Push-button switch
20	262182-00-9	Toggle switch (on-off)
21	289132-00-2	Control knob
	282413-00-6	10-32 x 3/16" Flat-point setscrew
22	239770-00-5	6-40 x 1/4" Fillister-head screw
23	285319-00-0	Cord clamp
24	276273-00-1	Tension shaft
25	220021-00-7	6-40 x 1/4" Flat-head screw
26	276276-00-0	Tension-shaft clamp
28	243040-00-8	#6 Lockwasher
29		Balancing motor assembly
	296871-00-1	0.4 second pen-speed motor (120 volt, 50-60 cycle) old style
	308351-00-2	0.4 second combination balancing motor-feedback generator
	304989-00-2	Pinion
	296873-00-4	1-second pen-speed motor and gear train complete
	296871-00-1	1000 rpm motor (120 volt, 50-60 cycle)
	334001-00-5	1700 rpm motor (115 volt, 50-60 cycle) - Series "N" Amplifier
	297638-00-9	Gear complete (72T-64P)
	301546-00-2	Pinion
	331878-00-3	1-second pen speed worm gear drive complete
	341598-00-3	Motor only
	304567-00-0	Worm only
	304564-00-1	Clutch assembly
	296848-00-0	3-second pen-speed motor and gear train complete
	296600-00-8	1100 rpm motor with pinion (120 volt, 60 cycle)
	334059-00-3	1600 rpm motor (115 volt, 50-60 cycle) - Series "N" Amplifier
	296868-00-0	Gear complete (88T-64P)
	296849-00-6	4.5-second pen-speed motor with pinion (120 volt, 60 cycle)
	296600-00-8	1100 rpm motor with pinion (120 volt, 60 cycle)
	296859-00-1	Gear complete (140T-64P)
	331424-00-2	12-second pen-speed motor complete
	296872-00-8	1000 rpm motor
	297647-00-8	Gear complete (120T-48P)
	303425-00-8	Pinion and gear
	296874-00-0	24-second pen-speed motor and gear train complete
	296872-00-8	1000 rpm motor (120 volt, 60 cycle)
	297652-00-1	Gear complete (88T-64P, 15T-48P)
	297647-00-3	Gear complete (120T-48P)
30		Motor pinion
	291930-00-0	for instruments with 24-second pen travel
	291930-00-0	for instruments with 12-second pen travel
	286036-00-2	for instruments with 4.5-second pen travel
	291932-00-2	for instruments with 3-second pen travel
	304988-00-6	for instruments with 0.4-second pen travel
	286029-00-6	Terminal block
	286031-00-0	Marking strip
	245081-00-3	Spacers
	241519-00-4	Screws
	286030-00-4	Cover
	210075-00-7	Washer
	243040-00-8	Washer

KEY TO FIGURE 4.

BE SURE TO STATE MODEL AND SERIAL NUMBERS OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
1	298350-00-9	Mounting frame
2	266541-00-3	10-32 x 1/2" Fillister-head screw
3	291089-00-3	6-40 x 1/4" Special-head screw
4	289118-00-0	Clamp
5	289112-00-1	Post
10	286053-00-4	Motor mounting nuts
11	285272-00-4	Gear stop
12	285273-00-0	Cable clamps
13	239770-00-5	6-40 x 1/4" Fillister-head screw
14	210075-00-7	Washer
15	289660-00-9	1/4" -20 x 1/2" Hex-cap screw
16	291678-00-9	Cable cover
17	295612-00-2	Terminal block marking strip (8 point)
18	295611-00-6	Terminal block
19	245081-00-3	Spacer
20	295614-00-5	Cover, terminal block
21	243040-00-8	#6 Lockwasher
22	241519-00-4	6-40 x 3/4" Fillister-head screw
23	266539-00-9	10-32 x 3/8" Fillister-head screw
24	286014-00-9	Post
25	305078-00-3	Thrust washer
26	289117-00-3	Retaining ring
27	289865-00-0	Cover for slidewire
	303805-00-5	Cover for slidewire (used on .4 second instruments)
29	293034-00-1	Balancing mechanism shaft (560)
	296809-00-4	Balancing mechanism shaft (570) deep case only
	304010-00-6	Balancing mechanism shaft (570 double front set)
	304008-00-1	Balancing mechanism shaft (573 & 574 0.4 sec. instruments)
	305080-00-8	Bearing
30	295425-00-8	Washer
31	295424-00-1	Post
32		Slidewire trimmer, give model, range and serial number of instrument
34	251556-00-0	4-48 x 5/16" Fillister-head screw
35	305079-00-0	Cover plate for bearing
	301872-00-7	Mounting screws
36		Slidewire complete, specify model, range and serial number of instrument
37	As req'd.	Contact arm (specify model, range and serial number)
38	282381-00-7	Washer
39	255785-00-3	10-32 Special thumb screw
40	265984-00-9	#10-32 x 1 1/2" Fillister-head screw
41	289104-00-9	Cover for slidewire
42	289113-00-8	1 or 2 pen ac-dc cover
43	219536-00-7	6-40 x 5/8" Fillister-head screw
	236344-00-5	6-40 x 5/8" Fillister-head screw for A-C instruments
44	240069-00-5	6-40 x 11/16" Fillister-head screw
45		Calibration spool, give model, range and serial number of instrument and information on label of spool
47	304951-00-5	12-Point terminal block
48	291089-00-3	6-40 x 1/4" Fillister-head screw
49	306016-00-1	Plug-in card
50	239770-00-5	6-40 x 1/4" Fillister-head screw
51	307136-00-0	Mounting strap
52	333547-00-4	Reference voltage source (Zener)
53	240066-00-6	8-32 x 1/4" Fillister-head screw
57	284245-00-3	Transformer (50-60 cycle) Standard a-c bridge
	298090-00-7	Transformer (50-60 cycle) As required for strain gauges
	291029-00-0	Transformer (50-60 cycle) As required for conductivity
60	285296-00-0	Latch pin
63	247042-00-5	10-32 x 1 1/8" Fillister-head screw
64	288141-00-8	Post
	239770-00-5	6-40 x 1/4" Fillister-head screw

NOTE: See att. TIII when two plug-in cards are required.

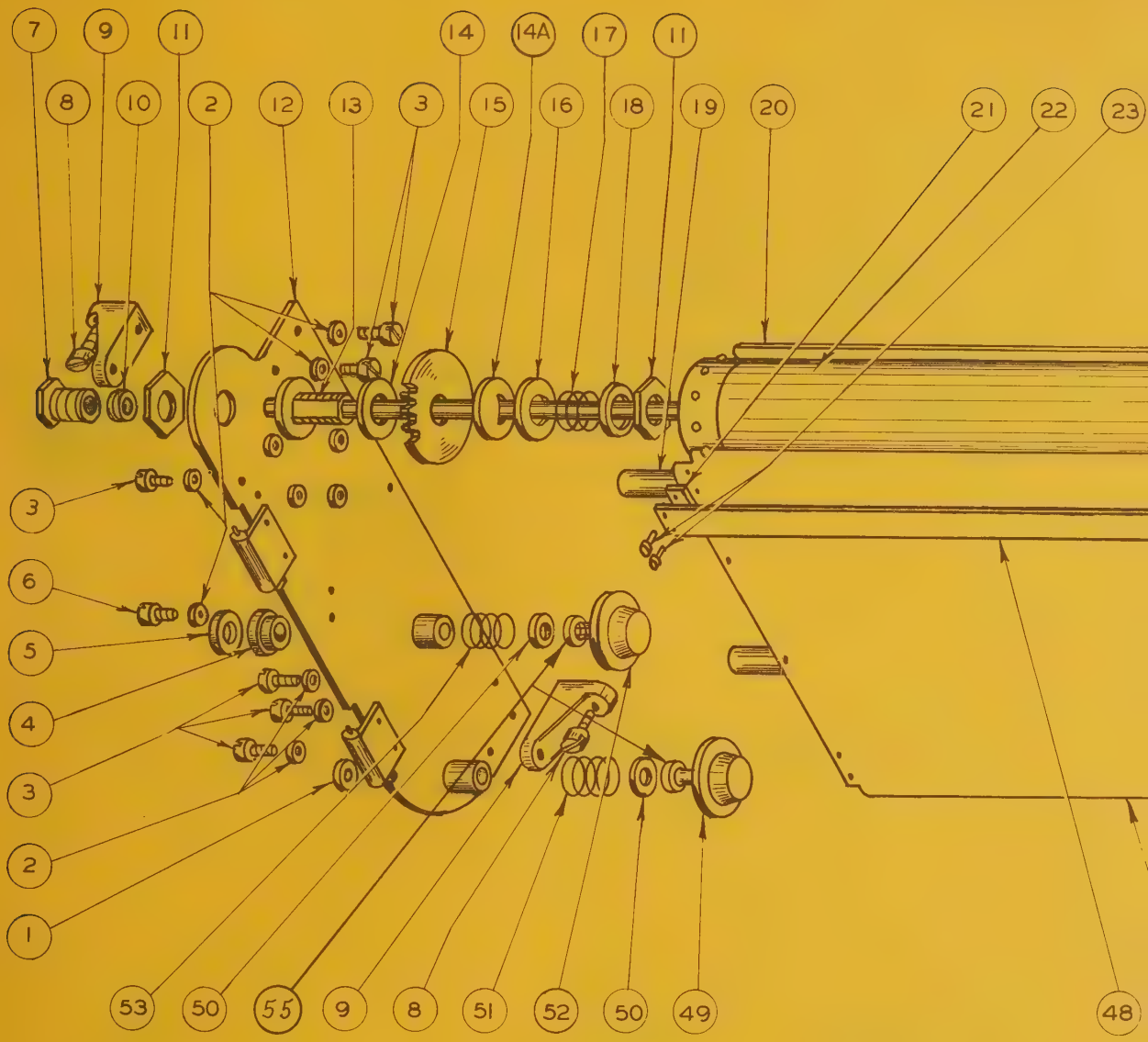
KEY TO FIGURE 5.

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
		Chart drive complete, without motor
	279220-00-6	with aluminum roll
	282424-00-8	with rubber covered roll
	351008-00-4	Swing out chart drive (for two-pen recorder)
1	272403-00-8	Retaining ring
2	235638-00-5	#10 Lockwasher
3	267029-00-4	10-32 x 5/16" Fillister-head screw
4	279208-00-6	Loading-spindle adjusting nut
	*282404-00-7	6-40 x 3/16" Flat-point setscrew for item 4
5	288885-00-7	Collar, not including setscrew
	*282404-00-7	6-40 x 3/16" Flat-point setscrew for item 5
6	239425-00-6	10-32 x 1/4" Special-head screw
7	279290-00-4	Bearing screw
8	266539-00-9	10-32 x 3/8" Fillister-head screw
9	279203-00-4	Foot for 1-pen and multiple-point instruments
	302078-00-2	Foot for 2-pen instruments
10	279291-00-0	Bearing
11	211386-00-6	Hexagon nut
12	279288-00-0	End plate (left hand) for all instruments except those with swing-out chart drive
	331465-00-0	End plate (left-hand) for 2-pen instruments with swing-out chart drive
13	279243-00-6	Shaft and hub complete
14	279236-00-0	Clutch facing
14A	305473-00-0	Washer
15	279241-00-3	Gear (80T-48P)
16	279237-00-6	Washer
17	279240-00-7	Spring
18	279235-00-3	Washer
19	279296-00-2	Chart-guide support rod (note: substitute item 43 for 2-pen instruments)
20	279295-00-6	Chart guide
	*230628-00-1	4-48 x 3/16" Fillister-head screw
21	294587-00-4	Spacer for chart cut-off plate
22	294030-00-0	Chart feed roll (aluminum)
	294031-00-6	Chart feed roll (rubber covered)
23	273927-00-0	2-64 x 7/32" Fillister-head screw
24	279231-00-8	Sprocket (26 tooth) not including setscrew
	*282414-00-2	10-32 x 1/4" Flat-point setscrew
25	283895-00-4	Bearing nut
26	283849-00-2	Sprocket (16 tooth)
27	221252-00-2	Washer
28	231427-00-0	6-40 x 5/16" Fillister-head screw
29	284743-00-3	Knob
	*311387-00-4	10-32 x 1/4" Nyloc cup-point setscrew
30	243040-00-8	#6 Lockwasher
31	279289-00-6	End plate (right hand) for 1-pen and multiple-point instrument
	302070-00-1	End plate (right hand for 2-pen instruments)
	*285216-00-7	Spring post } order assembled to end plate 302070-00-1
	*302071-00-8	Latch lever
	*243184-00-0	Shim
	*302074-00-7	Stud
	*285217-00-3	Stud
	*252618-00-9	Washer
	*242098-00-2	10-32 x 7/16" Fillister-head screw
	*285214-00-4	Latch spring for swing-out chart drive for 2-pen instruments
32	218339-00-3	6-40 x 3/16" Fillister-head screw
33	279205-00-7	Latch spring
	302075-00-3	Latch spring for 2-pen instruments
34	279250-00-2	Rewind knob, not including setscrew
	*303832-00-2	10-32 x 1/8" Flat-point setscrew
35	279247-00-1	Thrust washer
36	295498-00-5	Rewind shaft
37	279257-00-7	Thrust washer
38	279253-00-1	Spring
39	279252-00-5	Sprocket (16 tooth) and hub
40	279248-00-8	Clutch facing
41	279256-00-0	Loading spindle
42	282380-00-0	Spring housing
43	279282-00-1	Brace rod
44	279238-00-2	Spring
45	279200-00-5	Spring-tension nut
46	279228-00-7	Chain

*Not Shown

(continued on page 9)



ITEM	PART NO.	DESCRIPTION
47	279284-00-4	Chart plate (note: when used with chart cut-off guide, order drilled per sheet 294426-00-0
48	294586-00-8	Chart cut-off guide
49	279263-00-7	Rewind spindle
50	279265-00-0	Spring collar
51	279264-00-3	Spring
52	305077-00-7	Loading spindle
53	279232-00-4	Spring
	*263891-00-3	Chart rewind tube (cardboard)
	*286021-00-5	Chart clip
54	210075-00-7	Washer, fits over item 26
55	305785-00-1	Washer

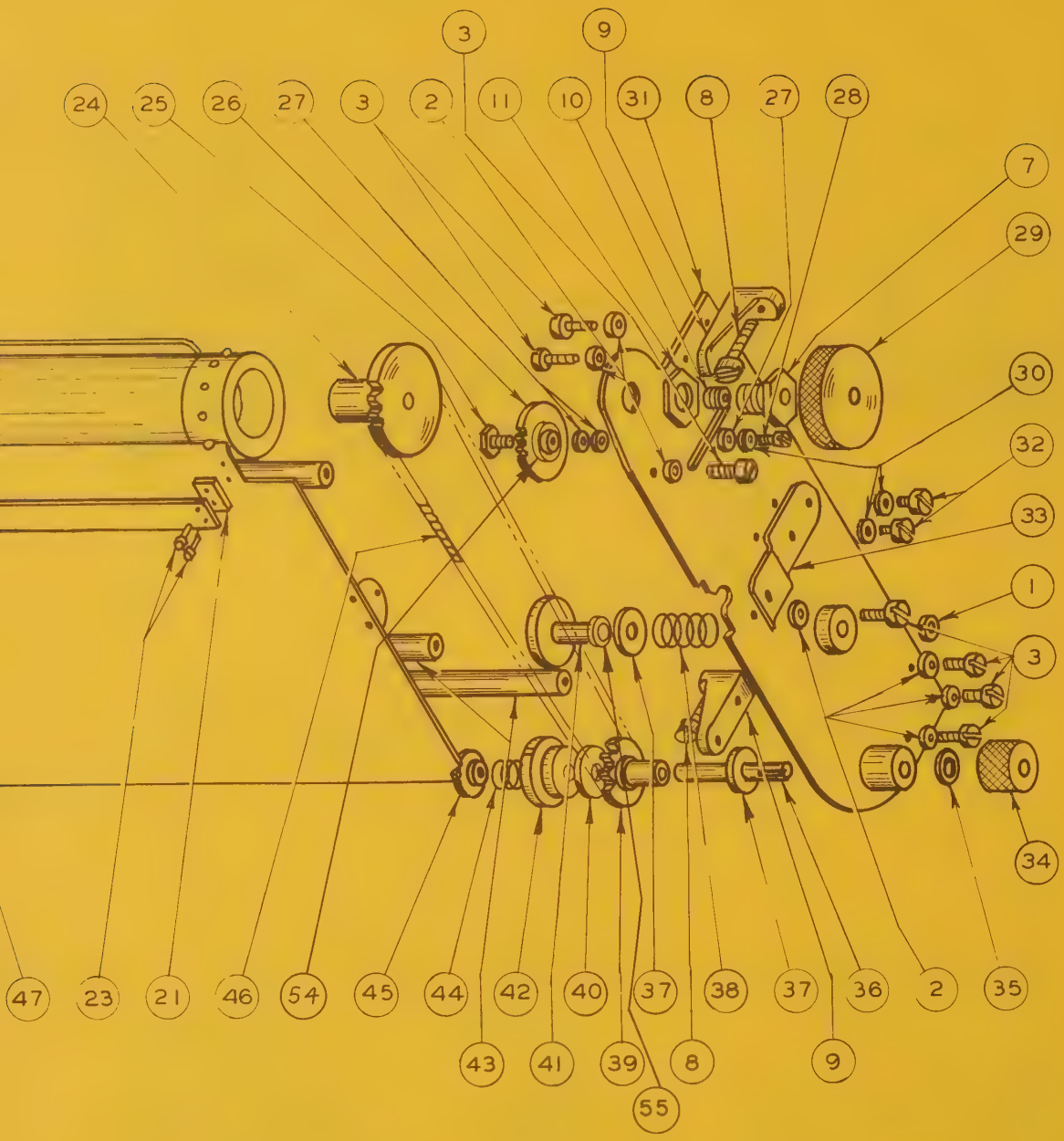


FIGURE 5. CHART-DRIVE MECHANISM WITHOUT MOTOR

NOT SHOWN PARTS FOR SWING OUT CHART DRIVE FOR 2-PEN INSTRUMENTS

331155-00-1	Hinge
266562-00-0	10-32 x 3/8" Flat-head screw for mounting hinge, part #331155-00-1
266539-00-9	10-32 x 3/4" Fillister-head screw for mounting hinge, part #331155-00-1
302079-00-9	Hinge pin
332414-00-0	10-32 x 1/4" Flat-point setscrew
331502-00-3	Tie bar (Lower)
331503-00-0	Tie bar (Upper)
296866-00-8	10-32 Shoulder screw
286324-00-8	10-32 x 1/2" Hexagon-socket cap screw

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

KEY TO FIGURES 6. THRU 9.

ITEM	PART NO.	DESCRIPTION
1	279209-00-2	Knurled nut
	235638-00-5	Lockwasher
2		Change gears (see table figure 21)
3	279210-00-0	Change-gear collar, not including setscrew
	*282403-00-0	6-40 x 1/8" Flat-point setscrew for item 3
4	266372-00-7	#6-40 Shoulder screw
5	235638-00-5	#10 Lockwasher
6		Left-hand chart-drive plate (see figure 5, item 12)
7	243040-00-8	#6 Lockwasher
8	219536-00-7	6-40 x 5/8" Fillister-head screw
9	239770-00-5	6-40 x 1/4" Fillister-head screw
10	309062-00-4	Gear train complete
11	309061-00-8	Gear train complete
12		Gear train complete
	341021-00-8	60:1 ratio
	341022-00-4	30:1 ratio
	341023-00-0	10:1 ratio
13	301531-00-5	Mounting plate for two-speed chart-drive motor
14	253086-00-0	Motor pinion (14T-48P) (not including setscrew) for low-speed chart drive
	251590-00-3	Motor pinion (16T-48P) (not including setscrew) for high-speed chart drive
	301532-00-1	Motor pinion (16T-48P) (not including setscrew) for 2-speed chart drive
	282403-00-0	6-40 x 1/8" Flat-point setscrew for above
17	266372-00-7	6-40 Shoulder screw
*18		Chart drive motors
	286058-00-6	Telechron C5 (120 volt, 60 cycle, 2 rpm)
	286059-00-2	Telechron C5 (120 volt, 50 cycle, 2 rpm)
	292110-00-6	Telechron C5 (120 volt, 60 cycle, 4 rpm)
	292111-00-2	Telechron C5 (120 volt, 50 cycle, 4 rpm)
	296738-00-0	Holtzer-Cabot RWC2505 (120 volt, 60 cycle, 4 rpm)
	332274-00-4	Holtzer-Cabot RBC2505 (120 volt, 50 cycle, 4 rpm)
	288060-00-8	Holtzer-Cabot RWC2505 (120 volt, 60 cycle, 10 rpm)
	332275-00-0	Holtzer-Cabot RBC2505 (120 volt, 50 cycle, 10 rpm)
	253680-00-0	Holtzer-Cabot RWC2505 (120 volt, 60 cycle, 60 rpm)
	254603-00-9	Holtzer-Cabot RWC2505 (120 volt, 50 cycle, 60 rpm)
	292128-00-2	Holtzer-Cabot RWC2510 (120 volt, 60 cycle, 60 rpm)
	331277-00-0	Holtzer-Cabot RBC2505 (120 volt, 60 cycle, 1 rpm)
	331276-00-3	Holtzer-Cabot RBC2505 (120 volt, 60 cycle, 2 rpm)
	331279-00-2	Holtzer-Cabot RBC2510 (120 volt, 60 cycle, 60 rpm)
	255327-00-5	Bodine (120 volt, 60 cycle, 4 rpm)
19	279278-00-4	Locating ring
20	202420-00-0	Washer (3 required)
21	294855-00-9	8-32 Hex nut (3 required)
33	279854-00-5	Retaining ring
40	237751-00-3	6-40 x 5/8" Flat-head screw
49	213256-00-2	Collar
50	220335-00-1	6-40 x 5/16" Flat-head screw

*Not Shown

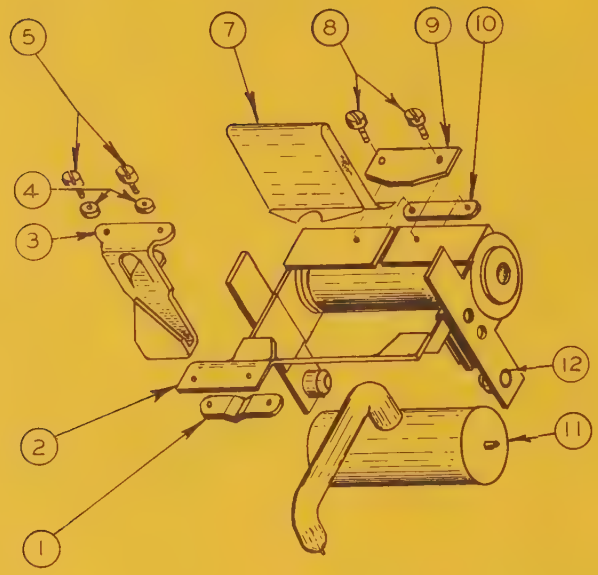


FIGURE 10. PEN ASSEMBLY FOR A STANDARD 1-PEN RECORDER

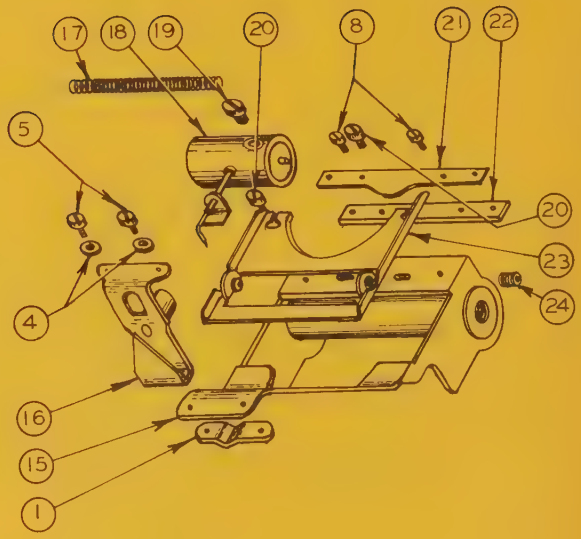


FIGURE 11. PEN ASSEMBLY FOR A 0.4 SEC. RECORDER

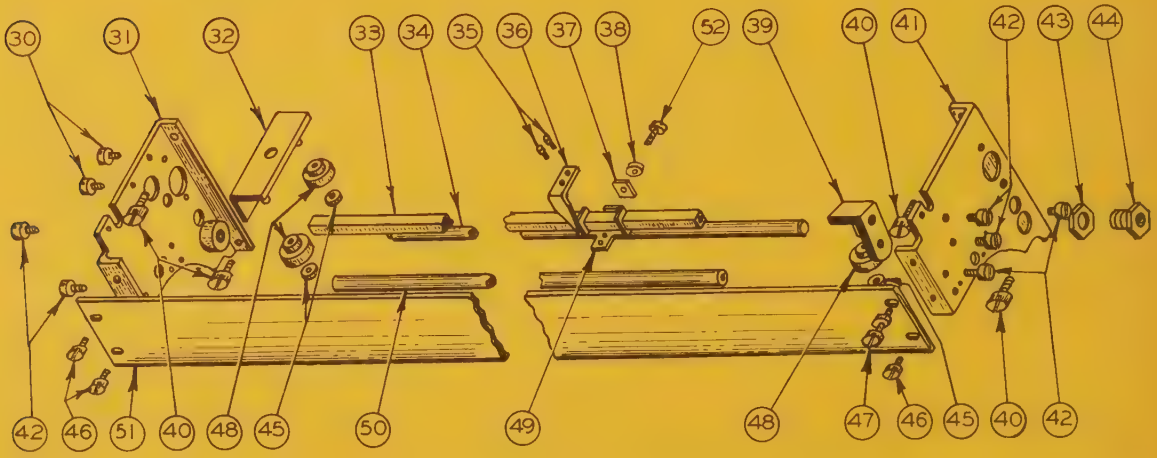


FIGURE 12. PEN-ASSEMBLY SUPPORT FOR A 1-PEN RECORDER

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

KEY TO FIGURES 10. THRU 12.

ITEM	PART NO.	DESCRIPTION
1	285230-00-0	Indicator clamp
2	293348-00-6	Pen-carriage assembly complete, less pen
3	285224-00-0	Indicator
4	237267-00-4	Washer
5	265071-00-3	3-56 x 1/8" Fillister-head screw
7	293358-00-1	Spring clip
8	230628-00-1	4-48 x 3/16" Fillister-head screw
9	285228-00-5	Cord clamp
10	285229-00-1	Strap
11	285206-00-1	Standard Pen (Glass)
	304935-00-1	Metal pen (large bore)
	295377-00-3	Metal pen (standard)
12	304595-00-4	Pivot screw
15	302212-00-0	Pen-carriage assembly complete, less pen (for 0.4-second pen speed)
16	302213-00-7	Indicator (for 0.4-second pen speed)
17	239890-00-0	Tension spring
18	302200-00-2	Pen for 0.4-second pen speed (includes item 19)
19	302211-00-4	Filter cap (included in item 18)
20	302218-00-9	Thumb screw
21	302222-00-6	Cord clamp
22	302223-00-2	Strap
23	331212-00-5	Pen mounting (includes item 24)
24	304595-00-7	6-32 Pivot screw (included in item 23)
30	218339-00-3	6-40 x 3/16" Fillister-head screw
31	285298-00-3	Left-hand support bracket (standard)
	302227-00-8	Left-hand support bracket complete (0.4 second pen speed)
		Left-hand support bracket only (0.4 second pen speed)
	301568-00-6	Pen-stop adjusting screw
	268556-00-8	10-32 Jam nut for adjusting screw
	247622-00-1	Washer for adjusting screw
	301567-00-0	Bumper, on end of adjusting screw
	266537-00-6	10-32 x 1/4" Fillister-head screw, to mount bracket 302225-00-0
	235638-00-5	#10 Lockwasher for above screw
32	288185-00-5	Control-Index-pulley bracket complete (includes items 45 and 48)
33	288188-00-4	Control-Index support rod
34	285271-00-8	Pen-support rod
35	293976-00-7	2-64 x 3/32" Fillister-head screw
36	288189-00-0	Control Index
37	288191-00-5	Indicator-cord clamp
38	276293-00-2	2-64 Thumb nut
39	288181-00-0	Control-index-pulley bracket complete, (includes items 45 and 48)
40	266539-00-9	10-32 x 3/8" Fillister-head screw
41	288249-00-3	Right-hand support bracket (standard)
	302224-00-9	Right-hand support bracket complete (0.4 second pen-speed)
42	239770-00-5	6-40 x 1/4" Fillister-head screw
43	285269-00-3	7/16"-27 Hex nut
44	285268-00-7	Bearing screw
45	279854-00-5	Retaining ring (3/16" shaft)
46	291089-00-3	6-40 x 1/4" Special-head screw
47	261682-00-8	6-40 Double-head screw
48	276283-00-7	Cord pulley
49	288190-00-9	Pointer bracket
	240018-00-1	2-64 x 1/4" Fillister-head screw
50	285256-00-9	Pen-carriage guide rod
51		Scale (order by model and serial number of instrument)
52	240018-00-1	2-64 x 1/4" Fillister-head screw

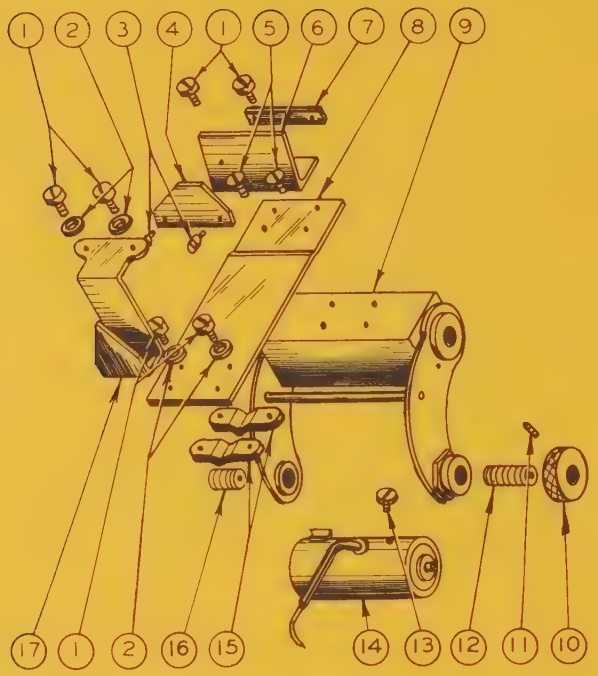


FIGURE 13. UPPER (NO. 2) PEN ASSEMBLY FOR 2-PEN RECORDER

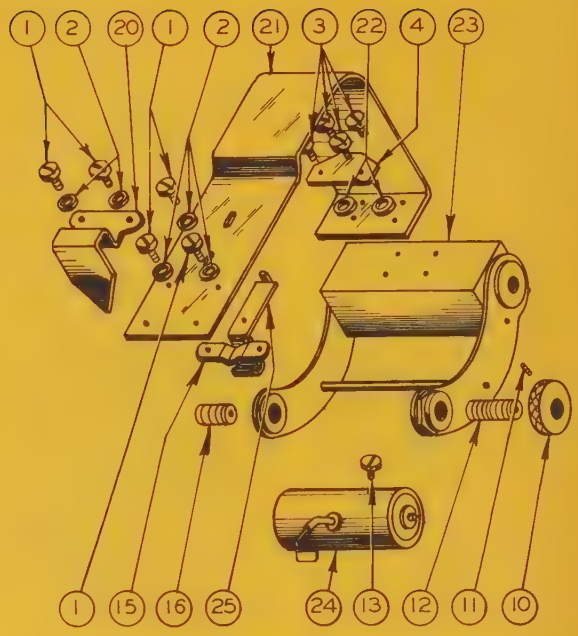


FIGURE 14. LOWER (NO. 1) PEN ASSEMBLY FOR 2-PEN RECORDER

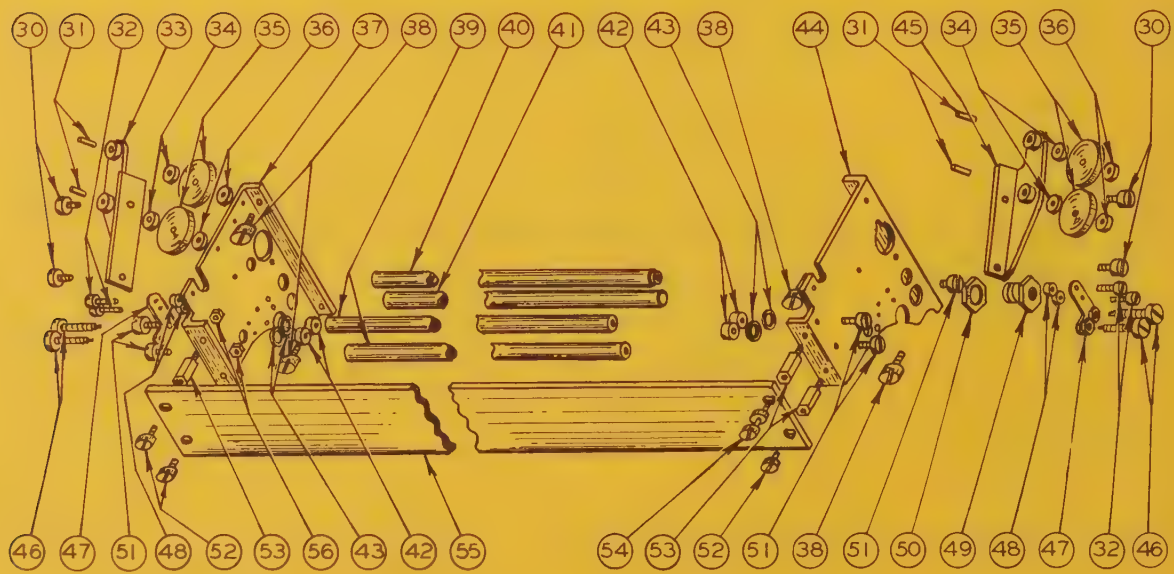


FIGURE 15. PEN ASSEMBLY SUPPORT FOR 2-PEN RECORDER

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

KEY TO FIGURES 13. THRU 15.

ITEM	PART NO.	DESCRIPTION
1	265071-00-3	3-56 x 1/8" Fillister-head screw
2	272103-00-4	Washer
3	261247-00-0	4-48 x 1/4" Fillister-head screw
4	285228-00-5	Cord clamp
5	220860-00-9	4-48 x 1/4" Flat-head screw
6	293399-00-0	Cord-clamp bracket
7	285229-00-1	Strap
8	302090-00-2	Indicator bracket (#2 pen)
9	331159-00-7	#2 Pen carriage (includes items 10, 11, 12 and 16)
10	302083-00-6	6-32 Thumb nut
11		6-40 x 1/8" Cone-point setscrew
12	302087-00-1	6-32 x 1/2" Pivot screw
13	302101-00-4	Filler cap
14	331162-00-8	#2 Pen (includes item 13)
15	285230-00-0	Indicator clamp
16	302084-00-2	6-32 x 3/8" Pivot screw
17	295872-00-4	Indicator (#2 pen, blue)
20	295871-00-8	Indicator (#1 pen, red)
21	302080-00-7	Indicator bracket (#1 pen)
22	245692-00-2	Washer
23	331158-00-0	#1 Pen carriage (includes items 10, 11, 12 and 16)
24	331161-00-1	#1 Pen (includes item 13)
25	293390-00-2	Indicator guide
30	218339-00-3	6-40 x 3/16" Fillister-head screw
31	285291-00-9	Pulley shaft for 3-, 7-, 12- and 24-second pen speeds
	302206-00-0	Pulley shaft for 1-second pen speed
32	264029-00-3	8-32 x 7/16" Fillister-head screw
33	292392-00-1	Cord-pulley bracket complete, left hand, for 3-, 7-, 12- and 24-second pen speeds (including items 31, 34, 35 and 36)
	298007-00-2	Pulley bracket only
	*282403-00-0	6-40 x 1/8" Flat-point setscrew
	303814-00-4	Cord-pulley bracket complete, left hand for 1-second pen speed (including items 31, 34 and 35)
	298007-00-2	Pulley bracket only
	*282403-00-0	6-40 x 1/8" Flat-point setscrew
34	228211-00-0	Spacer
35	292390-00-9	Pulley for 3-, 7-, 12- and 24-second pen speeds
	303811-00-5	Pulley for 1-second pen speed
36	279854-00-5	Retaining ring
37	293381-00-3	Left-hand support bracket
38	266539-00-9	10-32 x 3/8" Fillister-head screw
39	285256-00-9	Pen guide rod
40	293380-00-7	Pen support rod #2 pen
41	285271-00-8	Pen support rod #1 pen
42	301567-00-0	Bumper
43	247622-00-1	Washer
44	293382-00-0	Right-hand support bracket
45	292387-00-8	Cord-pulley bracket complete, right hand, for 24- 12- 7- and 3-second pen speeds (including items 31, 34, 35 and 36)
	298006-00-6	Pulley bracket only
	*282403-00-0	6-40 x 1/8" Flat-point setscrew
	303813-00-8	Cord-pulley bracket complete, right hand for 1-second pen speed (including items 31, 34 and 35)
	298006-00-6	Pulley bracket only
	*282403-00-0	6-40 x 1/8" Flat point setscrew
46	301568-00-6	Adjusting screw
47	302067-00-0	Bumper bracket
48	276302-00-1	Spacer
49	285268-00-7	Bearing
50	285269-00-3	Locknut
51	239770-00-5	6-40 x 1/4" Fillister-head screw
52	291089-00-3	6-40 x 1/4" Special-head screw
53	249767-00-7	Post
	295425-00-8	Washer
54	261682-00-8	Double-headed screw
55		Scale (order by model and serial number of instrument)
56	220903-00-0	6-40 Hexagon nut

*Not Shown

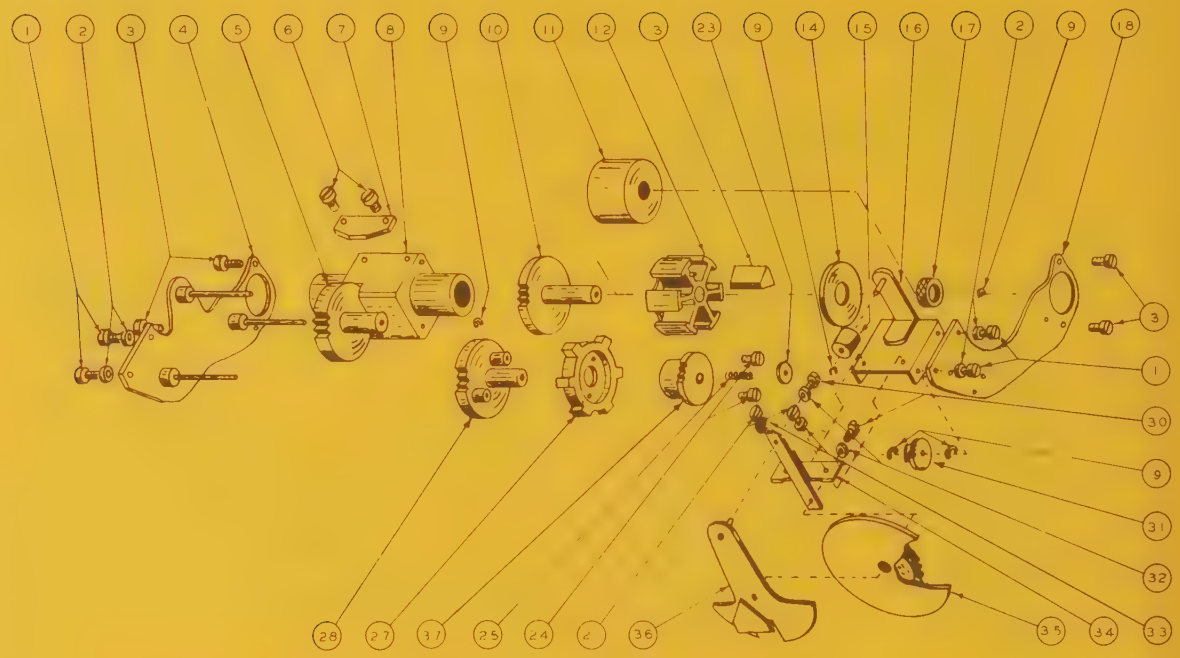


FIGURE 16. MULTIPLE-PRINTING MECHANISM

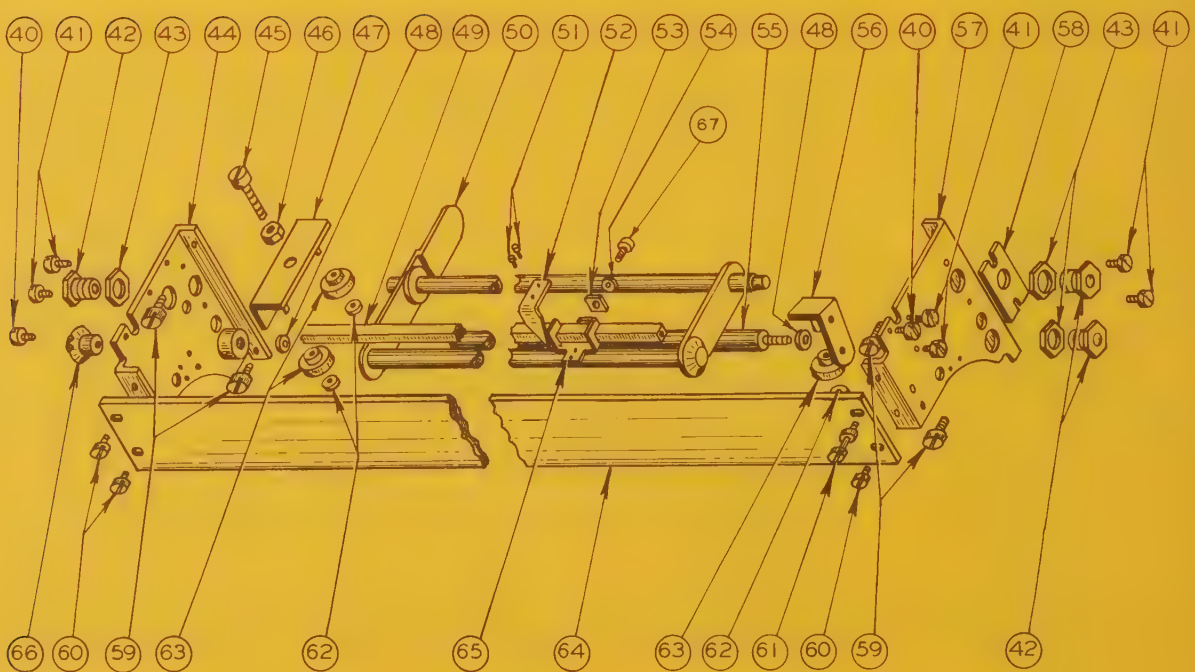


FIGURE 17. PRINTING MECHANISM SUPPORT FOR MULTIPLE-POINT RECORDER

KEY TO FIGURES 16. & 17.

ITEM	PART NO.	DESCRIPTION
1	237603-00-4	2-64 x 3/16" Fillister-head screw
2	268791-00-7	#2 Lockwasher
3	210626-00-3	4-48 x 1/8" Fillister-head screw
4	285263-00-5	Left-hand plate
5	286072-00-9	Gear (48T-48P)
6	230628-00-1	4-48 x 3/16" Fillister-head screw
7	285228-00-5	Cord clamp
8	285235-00-1	Frame
9	280607-00-8	Retaining ring (1/8" shaft)
10	288197-00-3	Gear (48T-48P)
11	294449-00-0	Container of 5 rolls for 1-color printing (purple)
12	268196-00-1	Felt-holder (6-segment)
	269626-00-0	Felt-holder (8-segment)
	294272-00-3	Felt-holder (12-segment) (Separate cap - part 294274-00-6)
13		INKING FELTS (CONTAINER OF 6)

	BLACK	RED	PURPLE	GREEN	BLUE	BROWN
6-segment	291000-00-2	291001-00-9	291002-00-5	291003-00-1	291004-00-8	291005-00-4
8-segment	291006-00-0	291007-00-7	291008-00-3	291009-00-0		
12-segment	294282-00-9	294283-00-5	294284-00-1	294400-00-1	294401-00-8	294402-00-4

14 DESIGNATION DISK

269545-00-0 - 2-point		269645-00-4 - 4-point	
268199-00-0 - 3-point		268198-00-4 - 6-point	

15	286070-00-6	Roller Complete	
16	285293-00-1	Roller bracket complete	
17	268182-00-0	Thumb nut	
18	296762-00-8	Right-hand plate	
21	265071-00-3	3-56 x 1/8" Fillister-head screw	
23	223212-00-8	Washer	
24	273927-00-0	2-64 x 7/32" Fillister-head screw	
25	286066-00-9	Spring	
27	287374-00-9	Type wheel (dots only) 2, 3, or 6-point	
	287375-00-5	Type wheel (dots only) 4-point	

TYPE WHEEL (DOTS AND NUMBERS)

268193-00-2 - 2-point	268195-00-5 - 6-point	287841-00-6 - 12-point	315866-00-4 - 24-point
268194-00-9 - 3-point	269636-00-5 - 8-point	289872-00-6 - 16-point	
269637-00-1 - 4-point	294433-00-7 - 10-point	294440-00-3 - 20-point	

28	311397-00-0	Gear and hub (48P-48T)	
30	263800-00-8	1-72 Fillister-head screw	
31	297660-00-4	Idler gear	
32	242762-00-0	Washer	
33	296752-00-2	Washer	
	270694-00-5	Shakeproof washer	
34	296758-00-0	Mounting bracket	
35		Indexing disc	

296798-00-2 - 2-point	296788-00-7 - 6-point	296779-00-8 - 12-point	296770-00-0 - 24-point
296794-00-7 - 3-point	296785-00-8 - 8-point	296776-00-9 - 16-point	
296791-00-8 - 4-point	296782-00-9 - 10-point	296773-00-0 - 20-point	

36	296768-00-6	Shield and pointer	
37	296753-00-9	Idler drive gear	
	282403-00-0	6-40 x 1/8" flat-point setscrew	
40	239770-00-5	6-40 x 1/4" Fillister-head screw	
41	218339-00-3	6-40 x 3/16" Fillister-head screw	
42	285268-00-7	Bearing screw	
43	285269-00-3	7/16"-27 Hexagon nut	
44	285298-00-3	Left-hand support bracket	
45	266546-00-5	10-32 x 1" Fillister-head screw	
46	272055-00-0	10-32 Hexagon nut	
47	288185-00-5	Control-index pulley complete (including items 62 & 63)	
48	286048-00-0	Thrust washer	
49	288188-00-4	Control-index support rod	
50	286088-00-2	Depressor bar	
51	262795-00-0	2-64 x 3/32" Hexagon-head screw	
52	288189-00-0	Control index	
53	288191-00-5	Cord clamp	
54	276293-00-2	2-64 Thumb nut	
55	286078-00-7	Spline shaft	
56	288181-00-0	Control-index pulley complete (includes items 62 and 63)	
57	285249-00-2	Right-hand support bracket	
58	286091-00-3	Adjusting plate	
59	266539-00-9	10-32 x 3/8" Fillister-head screw	
60	291089-00-3	6-40 x 1/4" Special-head screw	
61	261682-00-8	6-40 Double-headed screw	
62	279854-00-5	Retaining ring (3/16" shaft)	
63	276283-00-7	Pulley	
64		Scale (order by model and serial number of instrument)	
65	288190-00-9	Control-index bracket	
66	244009-00-7	Miter gear	
67	240018-00-1	2-64 x 1/4" Fillister-head screw	

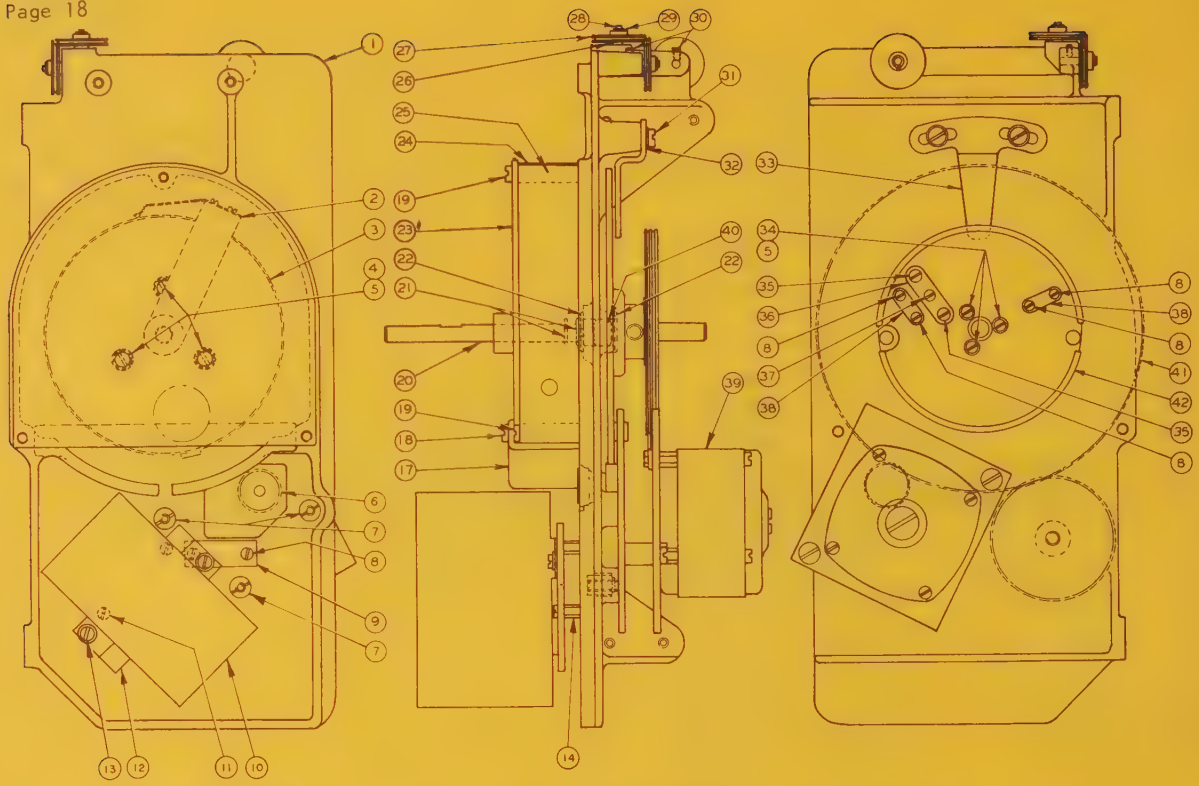


FIGURE 18. NO. 2 BALANCING MECHANISM FOR 2-PEN RECORDER

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
1	351007-00-8	Frame
2		Brush arm complete, specify model, range and serial no. of instrument
		Contact arm, specify model, range and serial no. of instrument
3		Slidewire (order by model and serial number of instrument)
5	243040-00-8	#6 Lockwasher
6		Motor pinion
	291930-00-0	For instruments with 24-second pen travel
	286036-00-2	For instruments with 7-second or 4.5 second pen travel
	291932-00-2	For instruments with 3-second or 1-second pen travel
	304988-00-6	For instruments with 0.4 second pen travel
7	286053-00-4	Motor-mounting nuts
8	239770-00-5	6-40 x 1/4" Fillister-head screw
9	289118-00-0	Cable strap
10	332767-00-0	Reference voltage source (Zener)
11	220335-00-1	6-40 x 5/16" Flat-head screw
12	307046-00-1	Mounting plate
13	306254-00-0	8-32 x 1/4" Fillister-head screw
14	249767-00-7	Post
15	293658-00-5	Index
16	268345-00-7	6-40 x 3/16" Special-head screw
17	302065-00-8	Cover
18	240066-00-6	8-32 x 1/4" Fillister-head screw
19	265984-00-9	10-32 x 1 1/2" Fillister-head screw
20	293034-00-1	Shaft
21	289117-00-3	Shaft retaining ring
22	224804-00-6	Thrust washer
23	302063-00-5	Slidewire back cover
24	289865-00-0	Slidewire cover
25	289112-00-1	Post for slidewire cover
26	228211-00-0	Washer
27	292390-00-9	Pulley for instruments with 3-, 4.5-, 7- and 24-second pen travel
	303811-00-5	Pulley for instruments with 0.4- and 1 second pen travel
28	285291-00-9	Pulley shaft
29	280607-00-8	Retaining ring
30	282403-00-0	6-40 x 1/8" Flat-point setscrew
31	267029-00-4	10-32 x 5/16" Fillister-head screw
32	210075-00-7	Washer

(continued on page 19)

KEY TO FIGURE 18. CONTINUED

BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENTS WHEN ORDERING PARTS

ITEM	PART NO.	DESCRIPTION
33	285272-00-4	Gear stop for instruments with 3-, 4.5-, 7- and 24-second pen travel
	293320-00-4	Gear stop for instruments with 0.4 and 1-second pen travel
34	231427-00-0	6-40 x 5/16" Fillister-head screw
35	220021-00-7	6-40 x 1/4" Flat-head screw
36	276276-00-0	Tension-shaft clamp
37	276273-00-1	Tension-shaft
38	285319-00-0	Cord clamp
39		Balancing motor
	296871-00-1	0.4 second pen speed motor (120 volt, 50-60 cycle)
	296873-00-4	1-second pen speed motor and gear train complete
	296871-00-1	1000 rpm motor (120 volt, 50-60 cycle)
	297640-00-3	Pinion (26T-64P) order with 6-40 x 1/8" flat-point setscrew No. 282403-00-0
	297638-00-9	Gear complete (72T-64P)
	296848-00-0	3-second pen speed motor and gear train complete
	296600-00-8	1100 rpm motor with pinion (120 volt, 60 cycle)
	296868-00-0	Gear complete (88T-64P)
	296849-00-6	4.5 second pen speed motor with pinion (120 volt, 60 cycle)
	296600-00-8	1100 rpm motor with pinion (120 volt, 60 cycle)
	296859-00-1	Gear complete (140T-64P)
	293699-00-3	7-second pen speed motor (120 volt, 60 cycle)
	296874-00-0	24-second pen speed motor and gear train complete
	296872-00-8	1000 rpm motor (120 volt, 60 cycle)
	297652-00-1	Gear complete (88T-64P, 15T-48P)
	297647-00-8	Gear complete (120T-48P)
40	286043-00-9	Needle bearing
41	302102-00-0	Bull gear complete for 3-, 4.5-, 7- and 24-second pen travel (includes setscrew and items 5, 8, 34 thru 38 and 42)
	286052-00-8	Bull gear and hub only for 3-, 4.5- 7- and 24-second pen travel
	331556-00-6	Bull gear complete for 1- and 0.4 second pen travel (includes setscrew and items 5, 8, 34 thru 38 and 42)
	293360-00-6	Bull gear and hub only for 1- and 0.4 second pen travel
	289049-00-8	5/16-18 x 5/16" flat point setscrew
42	302104-00-3	Sheave
	303696-00-1	Drive cord #2 pen

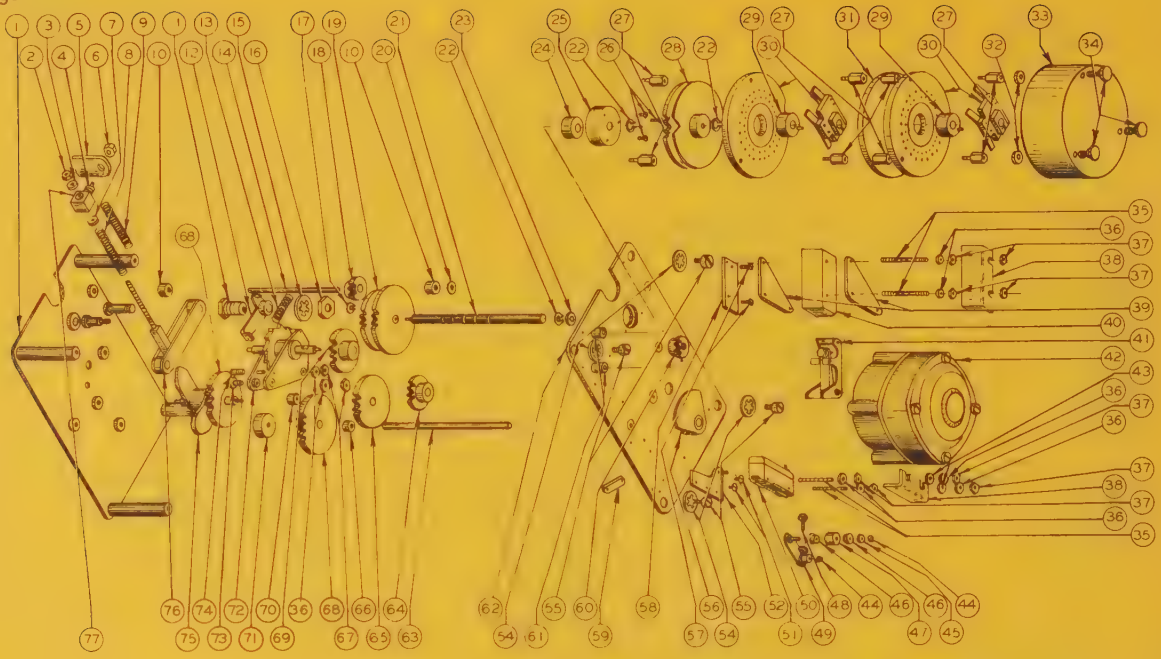


FIGURE 19. MULTIPLE-SWITCHING ASSEMBLY FOR MULTIPLE-POINT RECORDER

ITEM	PART NO.	DESCRIPTION
	341516-00-7	Multiple switching mechanism for 0.4 sec. Dynamaster only.
	298068-00-1	Dynamaster multiple switching mechanism complete for all instruments except those with battery standardizing, less motor & switch deck. Specify model & serial number of instrument.
	298069-00-8	Dynamaster multiple switching mechanism complete for all instruments with battery standardizing, less motor & switching deck. Specify model & serial number of instrument.
1	288004-00-0	Front plate complete
2	282647-00-7	6-40 Self-locking nut
3	288083-00-8	Yoke washer
4	288081-00-5	Depressor yoke
5	286088-00-2	Depressor bar
6	289653-00-2	Depressor-yoke nut
7	288082-00-1	Spring collar
8	288080-00-9	Printing pressure spring
9	270610-00-6	Printing-lever spring
10	253889-00-6	Collar, including setscrew
	282403-00-0	6-40 x 1/8" Flat-point setscrew for item 10
11	295557-00-1	Latch-lever adjustment nut (see item 12)
12	295556-00-5	Latch-lever complete, includes items 11, 15 and 16
13	288032-00-4	Latch-lever spring
14	288092-00-7	Miter-gear shaft
15	240262-00-0	Lockwasher
16	240278-00-3	5/16"-32 x 1/8" Hexagon nut
17	279854-00-5	Tru-Arc retaining ring
18	288056-00-0	Pinion complete including setscrew
	282403-00-0	6-40 x 1/8" Flat-point setscrew for item 18
19		Gear including setscrew
	305395-00-9	(50T x 84T - 48P) for 2-, 3-, or 6-point instrument
	305396-00-5	(60T x 84T - 48P) for 4- or 8-point instrument
	305397-00-1	(70T x 84T - 48P) for 10-point instrument
	305398-00-8	(75T x 84T - 48P) for 12-point instrument
	305399-00-4	(72T - 40P x 84T - 48P) for 16-point instrument
	305400-00-2	(95T x 84T - 48P) for 20-point instrument
	305401-00-9	(100T x 84T - 48P) for 24-point instrument
	282413-00-6	10-32 x 3/16" Flat-point setscrew for item 19
20	286048-00-0	Thrust washer
21	288084-00-4	Multiple-switching shaft for 560 Dynamaster
	296842-00-1	Multiple-switching shaft for Dynamaster Recorder deep case only
22	291015-00-0	Retaining ring
23	261381-00-8	Thrust washer
24	288085-00-0	Ball bearing
25	288086-00-7	Bearing housing

KEY TO FIGURE 19. CONTINUED

ITEM	PART NO.	DESCRIPTION
26	289037-00-0	4-48 x 3/8" Flat-head screw
27	288068-00-9	Post 7/16" long, not including threaded end
	289375-00-2	Post 9/16" long, not including threaded end
	288070-00-3	Post 5/8" long, not including threaded end
	288144-00-7	Post 1 5/32" long, not including threaded end
28	289000-00-9	Gear (120T-48P) and cam assembly
29	296132-00-4	Switch-blade collar
30	298011-00-0	Switch plate and contact arm for 2-3-4-6-8-12-24 point multiple
	298013-00-2	Contact arm only for above
	298014-00-9	Switch plate and contact arm for 10 & 20 pt. multiple
	298016-00-1	Contact arm only for 10 & 20 pt. multiple
	298017-00-8	Switch plate and contact arm for 16 pt. multiple
	298019-00-0	Contact arm only for 16 pt. multiple
31	288067-00-2	Separating plate
32	282381-00-7	Washer
33	288071-00-0	Switch cover for a-c Bridge type instruments
	288145-00-3	Switch cover for d-c Potentiometer type instruments
34	255785-00-3	10-32 x 3/8" Thumb screw
35	286086-00-0	Switch stud
36	279008-00-7	#6 Lockwasher
37	220903-00-0	#6-40 Hex. nut
38	289863-00-7	Switch cover
39	279634-00-5	Cam-follower plate
40	254866-00-0	Snap-action switch
41	279622-00-7	Cam follower complete
	*279621-00-0	Spacer }
	*288173-00-7	Cam-follower shaft } used with item 41
	*280607-00-8	Retaining ring }
42	288060-00-8	Motor, 120 volt, 50-60 cycle for 8-, 15- or 30-second print interval
	292128-00-2	Motor, 120 volt, 50-60 cycle for 1.0-, 1.9-, 2.3-, 3.9- or 4.5-sec. print interval
	296738-00-0	Motor, 120 volt, 50-60 cycle for 60-second print interval
43	221252-00-2	Washer
44	280607-00-8	Retaining ring (see item 49)
45	215536-00-2	Washer (see item 49)
46	270903-00-3	Oil-less bushing (see item 49)
47	298044-00-5	Cam roller (see item 49)
	298043-00-9	Cam roller complete, includes items 46 and 47
48	279626-00-2	6-32 x 7/16" Hex-head screw (see item 49)
49	298040-00-0	Cam-follower arm complete, includes items 44, 45, 46, 47 and 48 (see item 52)
50	298035-00-6	Snap-action switch
51	220335-00-1	6-40 x 5/16" Flat-head screw
52	298036-00-2	Cam follower complete (includes item 49)
54	235638-00-5	#10 Lockwasher
55	266537-00-6	10-32 x 1/4" Fillister-head screw
56	298070-00-6	Cam complete
57	221407-00-6	6-40 x 1/2" Flat-head screw
58	294890-00-9	Switch mounting plate
59	298053-00-4	Mounting strap
60	286018-00-4	Pinion (30T-48P) not including setscrew
	*282403-00-0	6-40 x 1/8" Flat-point setscrew for item 60
61	295911-00-0	Spacer
62	288001-00-1	Back plate complete
63	298072-00-9	Cam shaft
64		Motor pinion
	292129-00-9	(46T-48P) for 8-second print interval
	294261-00-1	(22T-48P) for 3.9-or 60-second print interval
	288061-00-4	(19T-48P) for 4.6- or 30-second print interval
	289150-00-0	(36T-48P) for 2.3- or 15-second print interval
	294460-00-4	(37T-48P) for 1.9-second print interval
	298000-00-8	(63T-48P) for 1.0-second print interval
	282413-00-6	10-32 x 3/16" Flat-point setscrew for item 64
65		Gear, including setscrew
	294263-00-4	(86T-48P) for 3.9- or 60-second print interval
	288014-00-6	(89T-48P) for 2.3- or 4.6-second print interval
	292131-00-3	(62T-48P) for 8-second print interval
	294462-00-7	(71T-48P) for 1.9-second print interval
	294464-00-0	(62T-48P) for 1.0-second print interval
	282413-00-6	10-32 x 3/16" Flat-point setscrew for item 65
66	253172-00-4	Collar, not including setscrew
	*282403-00-0	6-40 x 1/8" Flat-point setscrew
67	200772-00-7	6-40 Hex. nut
68	294515-00-3	Gear complete (74T-48P)

*Not shown

(continued on page 22)

KEY TO FIGURE 19. CONTINUED

ITEM	PART NO.	DESCRIPTION
69		Ratchet-shaft gear
	288037-00-6	(100T-48P) for 2-, 3- or 6-point instrument
	288072-00-6	(90T-48P) for 4- or 8-point instrument
	294427-00-7	(84T-48P) for 10-point instrument
	286076-00-4	(75T-48P) for 12-point instrument
	289874-00-9	(54T-40P) for 16-point instrument
	294435-00-0	(57T-48P) for 20-point instrument
	296116-00-9	(50T-48P) for 24-point instrument
	282413-00-6	10-32 x 3/16" Flat-point setscrew for item 69
70	288034-00-7	Cam roll
71	298031-00-0	Ball bearing
72	298027-00-3	Ratchet assembly complete, includes items 36, 67, 70, 71, 73 & 74
73	298032-00-7	Shoulder screw
74	298093-00-6	Stud
75	298073-00-5	Cam shaft assembly complete
76	288042-00-0	Printing lever complete
77	295913-00-2	Sleeve

	MOTOR (ITEM 42 FIG. 19)	GEAR			
PRINT INTERVAL	50-60 CYCLE	ITEM NUMBER	PITCH	NUMBER OF TEETH	PART NUMBER
1.0 sec.	292128-00-2	64 65	48 48	63 62	298000-00-8 294464-00-0
1.9 sec.	292128-00-2	64 65	48 48	37 71	294460-00-4 294462-00-7
2.3 sec.	292128-00-2	64 65	48 48	36 89	289150-00-0 288014-00-6
3.9 sec.	292128-00-2	64 65	48 48	22 86	294261-00-1 294263-00-4
4.5 sec.	292128-00-2	64 65	48 48	19 89	288061-00-4 288014-00-6
8 sec.	288060-00-8	64 65	48 48	46 62	292129-00-9 292131-00-3
15 sec.	288060-00-8	64 65	48 48	36 89	289150-00-0 288014-00-6
30 sec.	288060-00-8	64 65	48 48	19 89	288061-00-4 288014-00-6
60 sec.	296738-00-0	64 65	48 48	22 86	294261-00-1 294263-00-4

FIGURE 20. TABLE OF MOTORS AND CHANGE GEARS FOR MULTIPLE-SWITCHING ASSEMBLY

LOW SPEED GEAR TRAIN 120 V. 60 Cycle				HIGH SPEED GEAR TRAIN 120 V. 60 Cycle			Gear Position	Pitch	No. of Teeth	Part Number	Identification
2 RPM TELECHRON	4 RPM TELECHRON	10 RPM HOLTZER CABOT	60 RPM HOLTZER CABOT	4 RPM HOLTZER CABOT	10 RPM HOLTZER CABOT	60 RPM HOLTZER CABOT					
286058-00-6	292110-00-6	288060-00-8	253680-00-0	296738-00-0	288060-00-8	292128-00-2					
Chart Speed (inches/Hour)						Chart Speed (In./Min.)					
3/4	1 1/2	3 3/4	22 1/2	60	150	15	1 2	40 40	16 64	292105-00-2 292103-00-0	C H
1	2	5	30	80	200	20	1 2	48 48	24 72	279225-00-8 279223-00-5	J N
1 1/2	3	7 1/2	45	120	300	30	1 2	48 48	32 64	279218-00-1 279222-00-9	K M
2	4	10	60	160	400	40	1 2	40 40	32 48	279227-00-0 279221-00-2	E F
3	6	15	90	240	600	60	1 2	48 48	48 48	279224-00-1 279224-00-1	L L
4 1/2	9	22 1/2	135	360	900	90	1 2	40 40	48 32	279221-00-2 279227-00-0	F E
5	10	25	150	400	1000	100	1 2	40 40	50 30	294210-00-8 294212-00-0	G D
6	12	30	180	480	1200	120	1 2	48 48	64 32	279222-00-9 279218-00-1	M K
9	18	45	270	720	1800	180	1 2	48 48	72 24	279223-00-5 279225-00-8	N J
10	20	50	300	800	2000	200	1 2	32 32	50 15	294214-00-3 294216-00-6	B A
12	24	60	360	960	2400	240	1 2	40 40	64 16	292103-00-0 292105-00-2	H C

FIGURE 21. TABLE OF MOTORS AND CHANGE GEARS FOR SINGLE-SPEED CHART DRIVE

FAST SPEED GEAR TRAIN					CHANGE GEARS	
MOTOR SPEEDS (120 V. 60 Cy. only)					NUMBER OF TEETH	PART NUMBER
1 RPM	2 RPM	4 RPM	10 RPM	60 RPM		
331277-00-0	331276-00-3	296738-00-0 255327-00-5 (a)	288060-00-8	331279-00-2 253680-00-0 (a)		
CHART SPEED (inches per minute)				CHART SPEED (inches per second)		
1/4	1/2	1	2-1/2	1/4 (a)	16 64	302531-00-9 302529-00-4
1/3	2/3	1-1/3	3-1/3	1/3 (a)	24 72	301539-00-6 301536-00-7
1/2	1	2	5	1/2 (a)	32 64	301540-00-4 301544-00-0
2/3	1-1/3	2-2/3	6-2/3	2/3 (a)	32 48	302527-00-1 302526-00-5
1	2	4	10	1 (a)	48 48	301542-00-7 301542-00-7
1-1/2	3	6	15	1-1/2 (b)	48 32	302526-00-5 302527-00-1
2	4	8	20	2 (b)	64 32	301544-00-0 301540-00-4
3	6	12	30	3 (b)	72 24	301536-00-7 301539-00-6
4	8	16	40	4 (b)	64 16	302529-00-4 302531-00-9

(a) Used for two-pen Dynamasters, and with only the five speeds indicated.
(b) May run 1% slow.

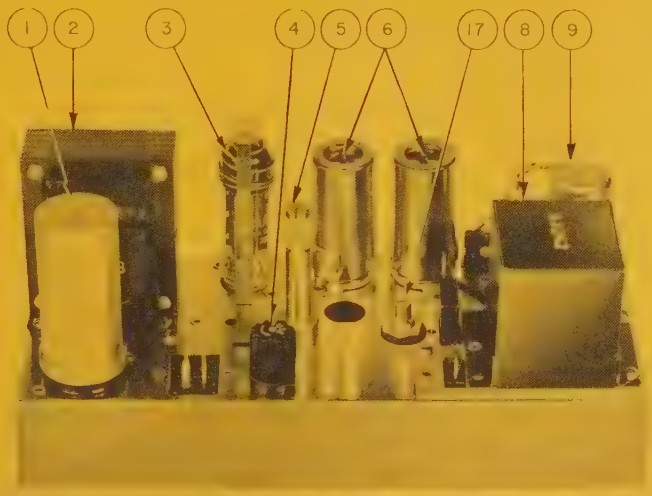
FIGURE 22. CHART SPEEDS & CHANGE GEARS FOR WIDE-STRIP DYNAMASTERS WITH 2-SPEED ATTACHMENT T84. MOTORS ARE HOLTZER-CABOT 120 V. 60 CYCLE.

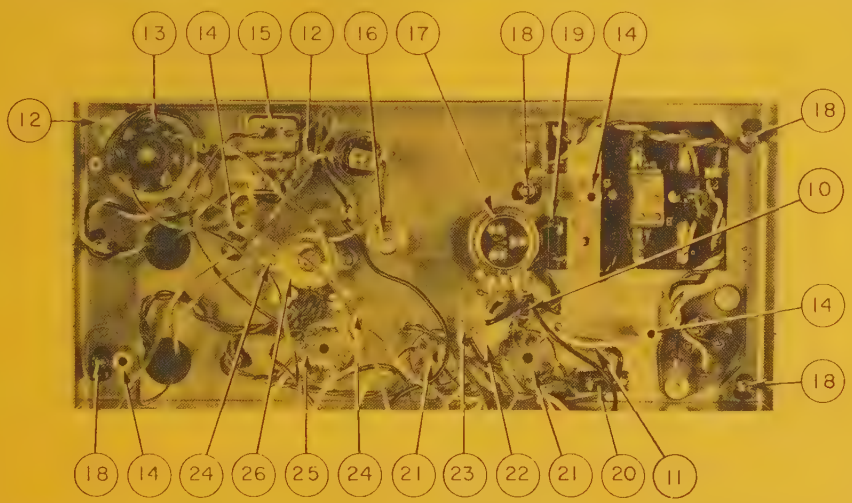
ITEMS NOT SHOWN

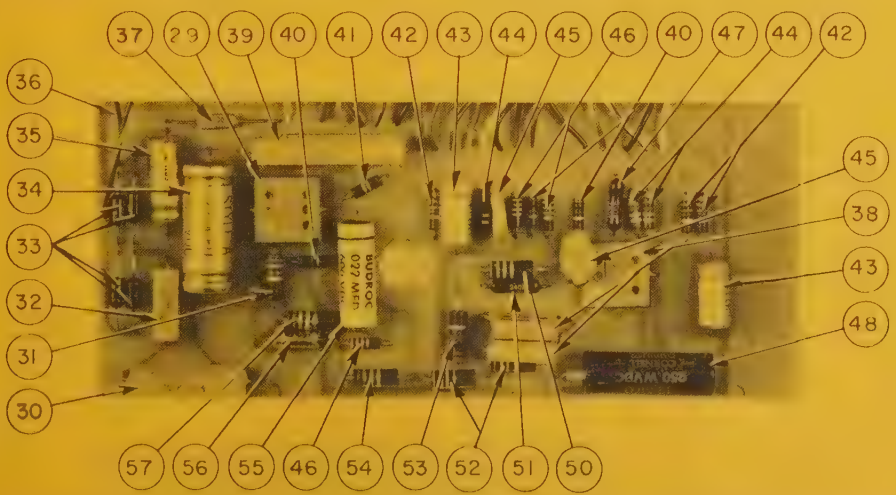
PART NO.	DESCRIPTION
342629-00-0	Power Pack for d-c resistance recorder
	AUTOMATIC PEN LIFTER (Attachment T6)
293336-00-8	Rotary solenoid
282096-00-0	Spring
334806-00-3	Rectifier
	PEN ACCESSORIES
308253-00-0	Ball Point pen (Red) } Screw in Type
308254-00-7	Ball Point pen (Blue) } Screw in Type
308255-00-3	Ball Point pen (Green) } Screw in Type
308256-00-0	Ball Point pen (Black) } Screw in Type
306500-00-0	2-ounce bottle of red ink
306502-00-3	2-ounce bottle of blue ink
306526-00-0	2-ounce bottle of black ink (reproducible)
306555-00-0	2-ounce bottle of green ink
370482-00-0	2-ounce bottle of purple ink
272693-00-0	Pen filler
303801-00-0	Pen starter
232900-00-0	Pen cleaner
	MISCELLANEOUS PARTS
298130-00-9	1/4-ounce bottle of Cramolin
305700-00-6	1-pint Bristol cleaning fluid (metal container)
291982-00-0	Bristol Motor Oil (plastic container)
289030-00-5	Drive cord

EDP 910120-94-3

SERIES L10, L11, L12, & L13 AMPLIFIERS







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BE SURE TO STATE MODEL AND SERIAL NUMBER OF INSTRUMENT WHEN ORDERING PARTS

ITEM	PART NUMBER	DESCRIPTION
	342366-00-9	Series "L10" Amplifier complete, 120V, 60 cy. (does not include input transformer or Syncroverter switch)
	342914-00-6	Series "L11" Amplifier complete, 120V, 50 cy. (does not include input transformer or Syncroverter switch)
	342915-00-2	Series "L12" Amplifier complete, 120V, 60 cy. with auxiliary gain control. (Does not include input transformer or Syncroverter switch).
	342916-00-9	Series "L13" Amplifier complete, 120V, 50 cy. with auxiliary gain control. (Does not include input transformer or Syncroverter switch.)
1	283974-00-1	Capacitor 10-10-10 mfd. 450V.
2	332653-00-5	Power transformer
3	310475-00-7	Tube 6B05
	310464-00-5	Tube hold down
4	309895-00-6	Fuse holder
	310485-00-2	Fuse 1/8 amp.
5	310474-00-0	Clamping screw
6	309675-00-6	Tube 6EU7
	302720-00-6	Tube shield
8		Input transformer, plug-in unit complete, (does not include Syncroverter switch)
	333240-00-6	100 ohms
	333241-00-2	1000 ohms
	333242-00-9	10,000 ohms
	333242-01-7	10,000 ohms
	333243-00-5	100,000 ohms
	333244-00-1	1,000 ohms (high isolation)
	333244-01-0	10,000 ohms (high isolation)
	333244-02-8	100,000 ohms (high isolation)
9	341415-02-2	Syncroverter switch
	305990-00-4	Shorting Plug (for models prefixed RB, RD, & RF)
10	283981-00-8	Resistor - 4.7 meg. 1/2 watt ±10% tolerance
11	308823-00-1	Resistor - 33 ohms, 3 watt ±5% tolerance
12	292359-00-4	Eyelet
13	271708-00-0	Tube socket
14	310472-00-8	Post
15	310462-00-2	Power plug
16	310473-00-4	Threaded bushing
17	310979-00-5	Gain control potentiometer
18	313234-00-0	Insert
19	312122-00-4	Socket
20	309555-00-0	Socket
21	310467-00-4	Tube socket, 9 pin (top mounting)
22	297631-00-4	Capacitor - .02 mfd. 1000V, (ceramic) ±20% tolerance
23	297630-00-8	Capacitor - 470 mmfd. 1000V, (ceramic) ±10% tolerance
24	236342-00-2	Eyelet
25	310468-00-0	Tube socket, 9 pin (bottom mounting)
26	310470-00-5	Potentiometer
29	370320-01-8	Capacitor - .003 mfd. 1000V. D.C. (mica) ±2% tolerance
30	297619-00-4	Resistor - 10K ohms, 7 watts, ±5% tolerance
31	310478-00-6	Resistor - 6.8K ohms, 1/2 watt, ±5% tolerance
32	297617-00-1	Resistor - 250 ohms, 3 watts, ±5% tolerance
33	370378-01-6	Diode (IN5061)
34	297627-00-7	Capacitor - .25 mfd. 600V. (paper) ±20% tolerance
35	312785-00-3	Capacitor - 50 mfd. 50V. (electrolytic) +75% -10% tolerance
36	332693-00-7	Printed circuit board assembly complete
	332692-00-0	Printed circuit board only
37	310479-00-2	Resistor - 400 ohms, 3 watts, ±5% tolerance
38	290592-00-3	Capacitor - .0062 mfd. (mica) ±5% tolerance, used on type L10 and L12
	293960-00-3	Capacitor - .0075 mfd. used on type L11 and L13
39	297620-00-2	Resistor - 22K ohms, 10 watts ±5% tolerance
40	283980-00-1	Resistor - 1 meg. 1/2 watt ±10% tolerance
41	272226-00-9	Resistor - 10K ohms, 1/2 watt ±10% tolerance
42	309880-00-9	Resistor - 3.3K ohms, 1/2 watt ±10% tolerance
43	310476-00-3	Capacitor - 50 mfd. 15 volt (electrolytic) +150% -10% tolerance
44	309881-00-5	Resistor - 220K ohms, 1/2 watt ±10% tolerance
45	297631-00-4	Capacitor - .02 mfd. 1000V. (ceramic) ±20% tolerance
46	283979-00-3	Resistor - 470K ohms, 1/2 watt ±10% tolerance
47	297685-00-7	Resistor - 300K ohms 1/2 watt ±2% tolerance
48	297624-00-8	Capacitor - 12 mfd. 250 volt (electrolytic) +150% -10% tolerance
50		Calibrating resistor
51	297684-00-0	Resistor - 240K ohms, 1/2 watt ±2% tolerance
52	289085-00-4	Resistor - 68K ohms, 1 watt ±10% tolerance
53		Calibration resistor
54	297682-00-8	Resistor - 56K ohms, 1 watt ±10% tolerance
55	297626-00-0	Capacitor - .022 mfd. 600V. (paper) ±10% tolerance
56	309591-00-7	Capacitor - 1 mfd. 6 volt (electrolytic) +150% -10% tolerance
57	297622-00-5	Resistor - 680K ohms, 1 watt ±5% tolerance

INSTRUCTION NO. Y19822

MOUNTING PROCEDURE FOR SERIES 590 RACK-MOUNTED DYNAMASTER

Mounting Procedure

To mount a rack-mounted Dynamaster, the door must first be removed by unfastening door stop and removing the upper hinge.

The instrument may then be mounted into the rack and fastened with screws furnished with the accessories. After the mounting screws are securely tightened, the door may be replaced and the door stop refastened.

The instrument is provided with four holes in the back of the case and four holes in the bottom of the case to accommodate standard conduit fittings.

ACCO BRISTOL DIVISION
WATERBURY, CONNECTICUT 06720

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INSTRUCTION NO. Y19208
ADJUSTMENT OF BLIND-SET ALARM CONTACTS
ATTACHMENT SPECS E51 THRU E57
USED ON SERIES 560, 565, 570, 571, 575 & 576 DYNAMASTERS

A. Description

Blind-set alarm switches are used primarily to operate alarms or signal lights and are entirely independent of any other control circuit that may be in the instrument.

These switches are actuated by cams and cam rollers and are located on the back of the hinged panel.

Instruments without controls may have from 1 to 9 alarm switches depending upon the model of the instrument.

Instruments with controls may have from 1 to 4 alarm switches depending upon the model of the instrument.

B. Wiring

A wiring diagram will be furnished with this instruction to cover the particular alarm circuit ordered. The alarm terminals are plainly marked on all instruments and correspond to the markings on the wiring diagram.

The power for operating the alarm may come from any source, such as a battery or an a-c power supply.

The maximum recommended capacity of the microswitches is as follows:

10 amperes	at 120 volts	a.c.
5 amperes	at 240 volts	a.c.
1/2 ampere	at 120 volts	d.c.
1/4 ampere	at 240 volts	d.c.

C. Adjustment

The switches are factory adjusted to operate at the point or points specified on the order. If it is necessary to change the operating point of the alarm switches, it may be done as follows:

Turn instrument power supply switch off. Move indicating pointer, by means of bull gear or motor pinion, to the point on the scale at which the first alarm is to operate. Loosen slightly the locking nut holding cams in position. Rotate cam until the cam-follower roller drops into the notch in the cam to operate the switch.

After the first switch is adjusted, shift indicating pointer to the point at which the second alarm is to operate. Then rotate second cam until cam-follower roller drops into the notch in the cam.

When all switches have been adjusted, retighten locking nut.

ACCO BRISTOL DIVISION
WATERBURY, CONNECTICUT 06720

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INSTRUCTION NO. P12170-23-A

24-POINT ELECTRIC SELECTOMATIC DYNAMASTER

MODEL 64A-24PG3X571 OR 64A-24PH3X571

Herewith: Diagram ~~850335-23-0~~ RF-212

Note: This instruction is supplementary to the standard Dynamaster instructions and covers the description and operation of the Electric Selectomatic Control.

A. Description

The 24-point Electric Selectomatic Dynamaster is an instrument for measuring from 1 to 24 variables. Selection of the points to be measured is made by omitting respective pins from a pin board located on the rear of the hinged panel.

The print time per point is variable from 0.8 seconds to 14.2 seconds with additional time of approximately 0.7 seconds for print dwell. Maximum speed is 36 seconds for printing all 24 points.

The instrument is basically a 1-second balance speed Dynamaster except for the multiple drive mechanism and print mechanism.

A special multiple switching mechanism with a solenoid for printing, a program unit with timer and rear panel with pin board for selection are used to accomplish an easy and flexible means for selecting any combination of points and print speed.

B. Operation

Refer to schematic wiring diagram.

The point selection is made thru a 48-point deck switch (24 point break before make) in combination with a selector pin board for a homing circuit for selection of point or points for print.

With power on, the multiple drive motor will operate to revolve switch deck wiper to an open point on the pin board. Simultaneously, the cam switch breaks, to stop the multiple motor and makes to energize timer. At end of time delay, timer contact closes energizing relay R1. Normally closed contact R1 operates to disconnect charging to print capacitor C2 and connects print solenoid to capacitor for operation.

Time delay relay R2 in series with normally open contact R1 provides a dwell to insure printing before restarting multiple motor to drive to next selected point. Normally closed contact R2 prevents timer from being energized on omitted points.

Caution: Do not make pin board selection when instrument is in operation. These contacts have sufficient current carrying capacity but will be damaged by making or breaking the circuit under load.

C. Print Solenoid Adjustment

To obtain proper or desired print pressure, a rheostat is provided on the program unit on the rear of case. The pressure should be decreased to give proper print by adjusting this rheostat. On high print speeds, the rheostat may require adjusting to obtain proper print pressure. On slower print speeds, the rheostat may require readjustments for a lighter print pressure.

Normally no readjustment is necessary for print speeds of 2 1/2 seconds up to maximum length of print time.

ACCO Bristol Division
Waterbury, Conn. 06720

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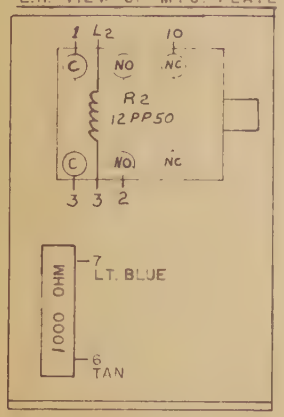
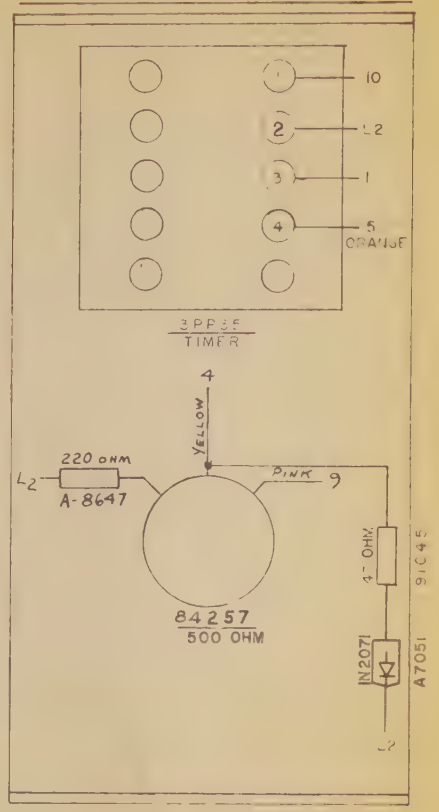
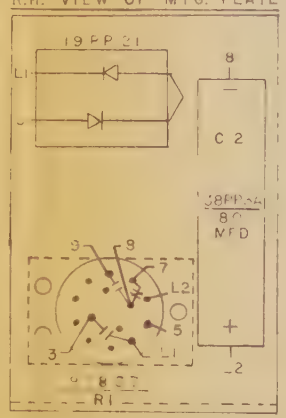
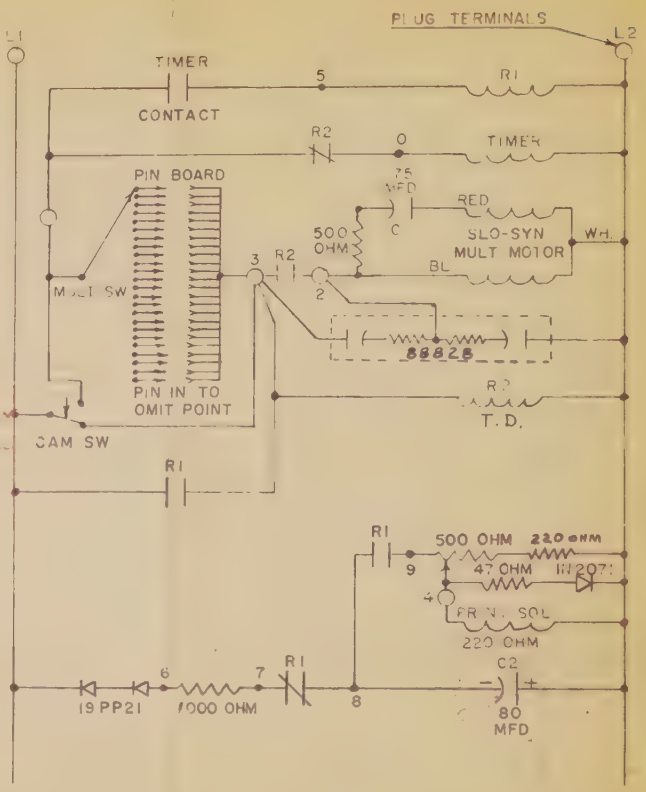




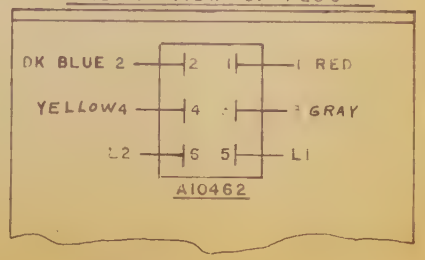


Cam Sw shown as Stepper switch in ~ position



CABLE & SOCKET COLOR CODE

PIN		
	1	RED
	2	BLUE
	3	GRAY
	4	YELLOW
	5	BLACK
	6	WHITE



C/N 02338

AM-187

		11-22-65	
	12-9-65	10-26-65	C-4-64

REVISIONS

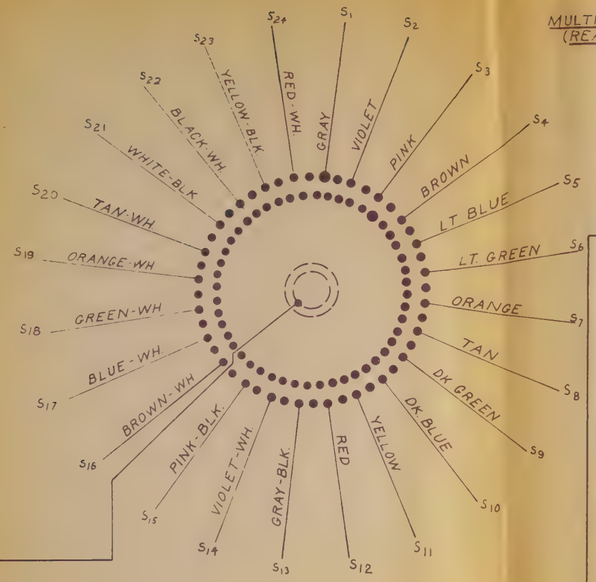
W.D. FOR CONTROL MODULE OF ELECTRIC SELECTOMATIC

THE BRISTOL COMPANY
WATERBURY, CONN. U.S.A.

DRAWN G E M	DATE 4-22-64	
TRACED	CHECKED	APPROVED
SCALE	FILE DR	
NO. RF-21		

150 IMPERIAL 64822

NOTE
1 SEE SEPARATE SHEET FOR MEASURING CIRCUIT WIRING
* FOR WIDE STRIP HIGH SPEED CHART DRIVES ONLY LIKE POINTS BETWEEN MULTIPLE SWITCH & POINT SELECTOR PINBOARD ARE CONNECTED TOGETHER



MULTIPLE SWITCH (REAR VIEW)

SUPPRESSOR > 88828

BLUE
GREEN
PINK

MOMENTARY SWITCH

DK BLUE 1
DK BLUE 1
CABLE "C"
NC
C
NO
GRAY
SLO-SYN SWITCHING MOTOR
PRINT SOLENOID
RED
.75 mfd
500Ω
WHITE
WHITE
YELLOW
BLACK
GRAY
BLACK
3 WIRE P.V.C.

PRINT SELECTOR PINBOARD (REAR VIEW)

S17 S9 S1
S18 S10 S2
S19 S11 S3
S20 S12 S4
S21 S13 S5
S22 S14 S6
S23 S15 S7
S24 S16 S8

1 RED
2 BLUE
3 GREEN
4 YELLOW
5 BLACK
6 WHITE
L1
L2

BLUE
GREEN
PINK

CABLE "A"
P3
SERIES "L" AMPLIFIER

P3
LOCATOR PIN
6 5
4 3
2 1

PIN COLOR CODE
1-RED
2-BLUE
3-GRAY
4-
5-BLACK
6-WHITE

BALANCE MOTOR INTERRUPTER SWITCH

WHITE
BLACK
RED
BLUE
GRAY
L2
L1
C1
M1
M2
L1
C2
GND

SUPPRESSOR
NO NC
BLUE
RED
WHITE
BLACK
BALANCING MOTOR

PROGRAM UNIT
P4

PIN COLOR CODE
1-RED
2-BLUE
3-GRAY
4-YELLOW
5-BLACK
6-WHITE

6 5
4 3
2 1
LOCATOR PIN

WHITE
BLACK
ON
OFF
INSTRUMENT ON-OFF SWITCH
SELECTOMATIC POWER (OPTIONAL)
BLACK
WHITE
L1 L2 GND

WHITE
GRAY
BLACK

CHART DRIVE
* CAP.
C1 L1 L2
WHITE
BLACK
CABLE "B"

CABLE "D"

MODEL	CABLE A	CABLE B	CABLE C	CABLE D
591	591175-01-0	590066-02-5	590885-07-3	590885-09-0

THIS PRINT CERTIFIED CORRECT
CUSTOMER
CUSTOMER ORD NO
CUST ITEM NO
BP REQ NO
SERIAL NO
DATE

ECO	ECO	DATE	DATE	REV. DATES
5115	4454	5-20-66	11-23-65	
8-2-68	+10-68	12-9-65	11-22-65	

DO NOT SCALE THIS PRINT
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE AFTER PLATING EDGES AND CORNERS .005" TO .010" NOM. RAD. TOLERANCES-FRACTIONS ± 1/64" DECIMALS ± .005" ANGLES ± 2°

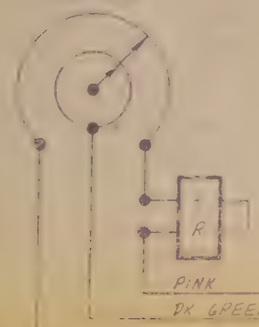
POWER WIRING DIAGRAM FOR ELECTRIC SELECTO-MATIC DYNAMASTER RECORDER.

THE BRISTOL COMPANY
WATERBURY 20, CONN. U.S.A.

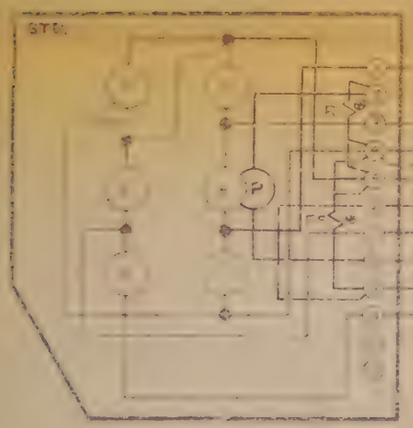
DRN R.L.A. DATE 8-25-65
TRCD CHECKED APP'D
CHK P.S.M.
PROJ DWN
SCALE FILE OR 300
NO. 021996

* S... SAFE AS REQ'D. 0 TO 5 UPSCALE ... DOWNSCALE
6 "X" AS REQ'D 2 TO 4 WITH UPSCALE F... TO 5 WITH
DOWNSCALE OR NO FAIL SAFE.

SLIDEWIRE



PINK
DK GREEN
DK BLUE



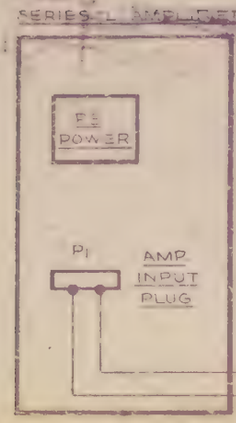
STANDARD BRIDGE

MULTIPLE SWITCH
(END VIEW)

REFERENCE VOLTAGE SOURCE

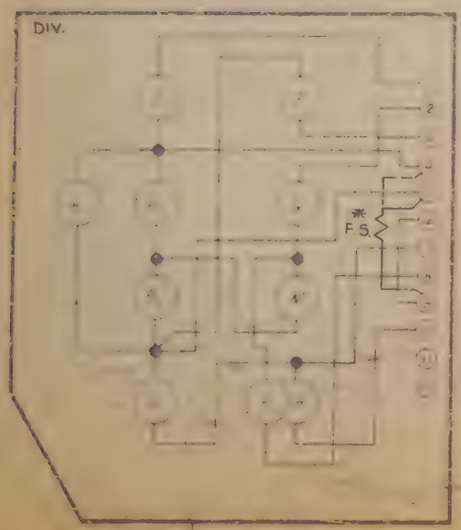
D END
NSATOR

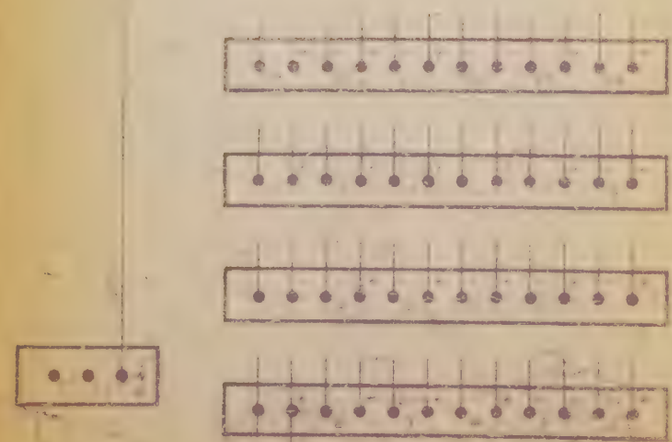
SERIES 'L' AMPLIFIER



THIS PRINT CERTIFIED CORRECT

CUSTOMER	
CUST ORD NO.	CUST ITEM NO.
BRISTOL CO. ORD. NO.	B/P #
MODEL NO.	SERIAL NO.
BY	DATE





CONVE
COMPENSATIN

NOTE

COMPENSATOR AS REQ'D PER CIRCUIT

"J"	(IRON-CONSTANTAN)	WHITE	RED
"K"	(CHROMEL-ALUMEL)	DK BLUE	RED
"T"	(COPPER-CONSTANTAN)	DK BLUE	RED
"S"	(PLAT-PLAT. 10% RHOD.)	DK BLUE	RED
"W"	(COPPER-COPPER)	DK BLUE	RED
"E"	(CHROMEL-CONSTANTAN)	WHITE	RED

ECO 9769
3-7-68

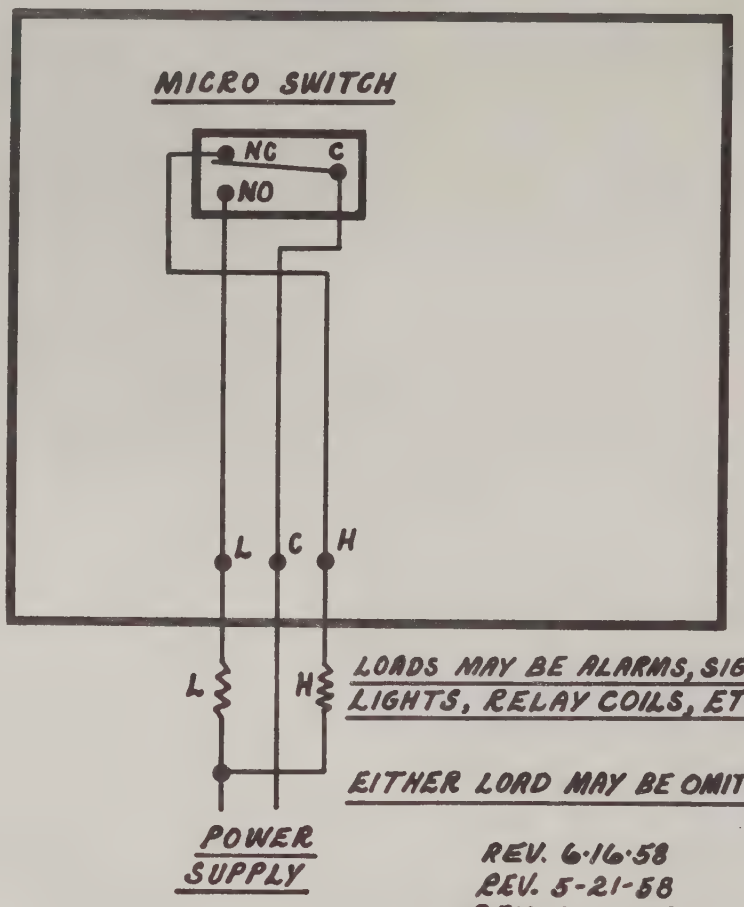
0E07603-24

FORM 1124

MAXIMUM RECOMMENDED CAPACITY OF MICRO SWITCHES

10 AMPS. AT 120 V. A-C
5 AMPS. AT 240 V. A-C
1/2 AMP. AT 120 V. D-C
1/4 AMP. AT 240 V. D-C

DYNAMASTER



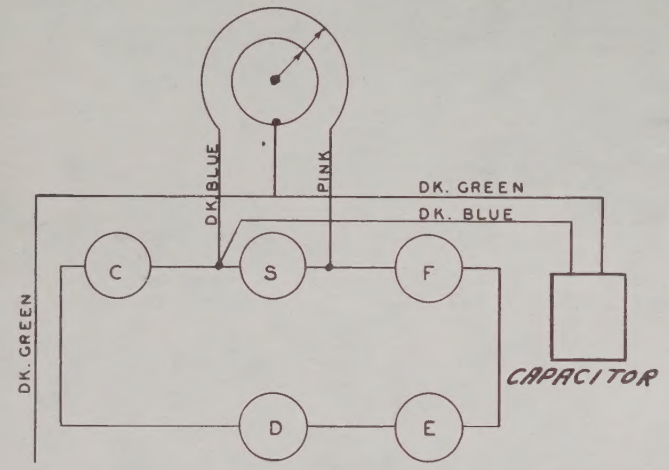
WIRING DIAGRAM FOR HIGH OR LOW ALARM CONTACTS (SPEC. E20, E22, E27, E35, E37, E42, & E51A T210, T211X, E87X).

REV. 6-16-58
REV. 5-21-58
REV. 6-10-57

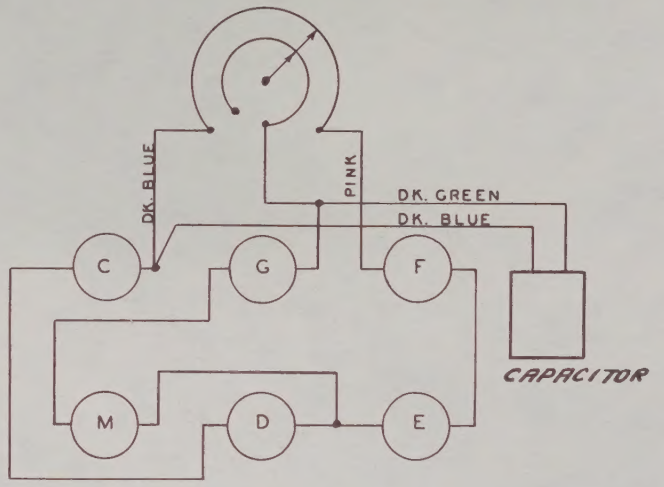
THE BRISTOL CO.
WATERBURY, CONN.
DATE 2-27-51 DRAWN I.J.F.
DRAWER NO. 21
SHEET NO. 012678

P. O. ORDER NO. _____ CUSTOMER ORDER NO. _____ SCHAL NO. _____

TYPICAL STANDARD BRIDGE



TYPICAL DIVIDER BRIDGE



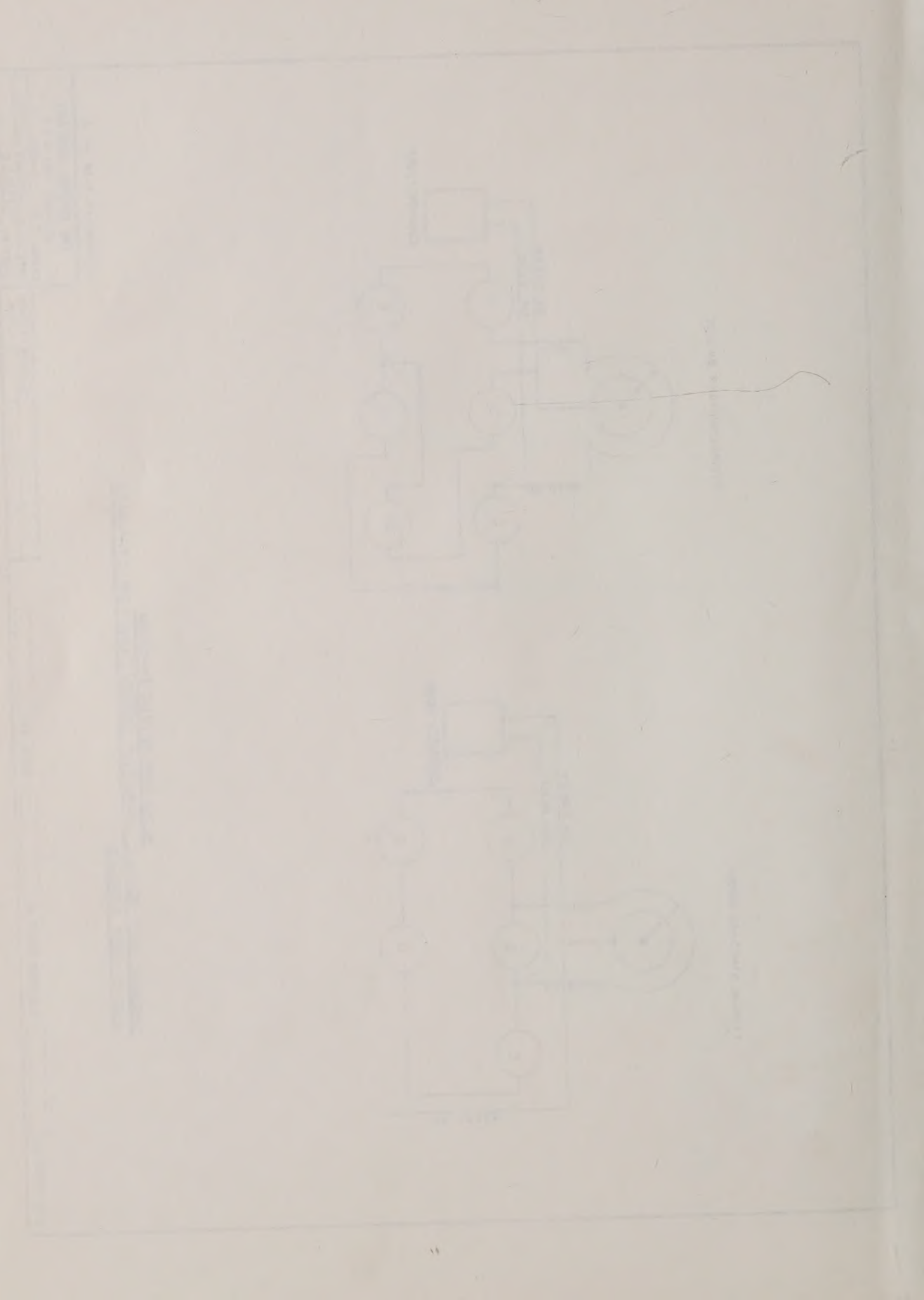
AUXILIARY WIRING DIAGRAM
SHOWING ANTI-BOUNCE CAPACITOR CONNECTIONS FOR STANDARD AND DIVIDER BRIDGES.

REDRAWN 12-4-58 H.I.S.

THE BRISTOL COMPANY
WATERBURY CONN. U. S. A.
DRAWN F. R. TRACED
DATE 10-30-55 DRAWER NO 122
SHEET NO 015058

B. CO ORDER NO
CUSTOMER ORDER NO
SERIAL NO.

4-17-59 REVISION DATES



PRODUCTS OF AMERICAN CHAIN & CABLE COMPANY INC.

INDUSTRIAL SUPPLIES & MACHINERY GROUP

American Welded & Weldless Chain and Attachments, ACCO Registered & Kuplex Sling Chains, Allison Abrasive Cut-Off and Grinding Wheels; Campbell Abrasive Cut-Off Machines; Hydraulic Presses, Nibbling Machines, Punches, Dies; Victor Masonry Cutting Saws and Blades; Malleable Iron Castings; Bristol Socket Screws; Maryland Bolts and Nuts; Weed Tire Chains

WIRE PRODUCTS GROUP

American Cable & Hazard Wire Rope, Wire Rope, Nylon, Dacron & Woven Wire Slings; Page Welding Wire; Strand; Manufacturers Wire; Aluminized Chain Link Fence; Tru-Lay Push-Pull Remote Controls; Automotive and Aircraft Cable Assemblies; Terminals; Tow Lines; SteerMaster Marine Steering Equipment; Clutch and Throttle Controls; Korodless Yacht Rigging

MATERIAL HANDLING GROUP

Mechanical Handling Systems, Automotive Power and Free, Tow Line, and Sortation Systems; Floor Lines and Overhead Trolley Conveyors; Driverless Tractors; Work Carriers and Storage Racks; Louden Monorail Cranes and Systems; Wright Hoists and Cranes; Mansover Grabs and Custom Engineered Hook Attachments; ACCO Chain, Wire Rope, Nylon, Dacron, and Woven Wire Slings, ACCO Custom Engineered Material Handling Equipment, Wire Rope and Cable Winches

INSTRUMENTS & ELECTRONICS GROUP

Bristol Automatic Controlling, Recording, Electronic and Telemetering Instruments; Syncroverter Choppers; Data-Master Digital and Computing Data Loggers; Solid State Supervisory Control Systems; High Speed Serial-Entry Printers; Electro-Mech Centralized Control and Annunciater Systems; ACCO Gyros, Accelerometers, and other Inertial Equipment; Helicoid Pressure Gages; Wilson "Rockwell" Hardness Testers

INTERNATIONAL GROUP

In Canada
DOMINION CHAIN COMPANY Limited, Stratford, Ontario
CANADIAN WARREN PINK division of Dominion Chain Company Limited
St. Catharines, Ontario and Vancouver, British Columbia
THE BRISTOL COMPANY OF CANADA Limited, Toronto, Ontario
CANADIAN MECHANICAL HANDLING SYSTEMS LTD., Windsor, Ontario

In England
MHS INTERNATIONAL, Inc., Watford, Herts
PARSONS CHAIN COMPANY Limited
BRITISH WIRE PRODUCTS Limited, Stourport-on-Severn, Worcestershire

In Mexico
INSTRUMENTOS BRISTOL, S.A. Mexico 7, D. F.

93508